Volume 43. MARCH, 1929. $4.00 a Year.
Number 1. Pages 1-112. $1.25 a Number.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY
THE NEW ENGLAND WATER WORKS ASSOCIATION,
714 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

Copyright, 1929, by the New England Water Works Association.

OFFICERS

OF THE

New England Water Works Association.

1928—1929.

PRESIDENT

ARTHUR D. WESTON, Principal Assistant Engineer,
Massachusetts Department of Public Health, Boston, Mass.

VICE-PRESIDENTS

ROBERT SPURR WESTON, of Weston & Sampson, Consulting Engineers, Boston, Mass.
(Term expires September, 1929)

GEORGE H. FINNERAN, Superintendent of Water Service, Boston, Mass.
(Term expires September, 1930)

DIRECTORS

GEORGE W. BREHM, City Engineer and Director of Public Works, Waltham, Mass.
(Term expires September, 1929)

ROGER W. ESTEY, Superintendent of Water Works, Danvers, Mass.
(Term expires September, 1929)

RICHARD H. ELLIS, Superintendent, Board of Public Works, North Andover, Mass.
(Term expires September, 1930)

KARL R. KENNISON, Designing Engineer,
Metropolitan District Water Supply Commission, Boston, Mass.
(Term expires September, 1930)

PAST PRESIDENTS
(Members of Executive Committee)

THEODORE L. BRISTOL, President Ansonia Water Company, Ansonia, Conn.
(Advisory Member)

FRANK E. WINSOR, Chief Engineer,
Metropolitan District Water Supply Commission, Boston, Mass.

SECRETARY

FRANK J. GIFFORD, Superintendent of Water Works, Dedham, Mass.

TREASURER

ALBERT L. SAWYER, Water Registrar, Haverhill, Mass.

EDITOR AND ADVERTISING AGENT

GORDON M. FAIR, Harvard University, Cambridge, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Life Member shall be a member whose service to the Association entitles him to special recognition by the Association.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

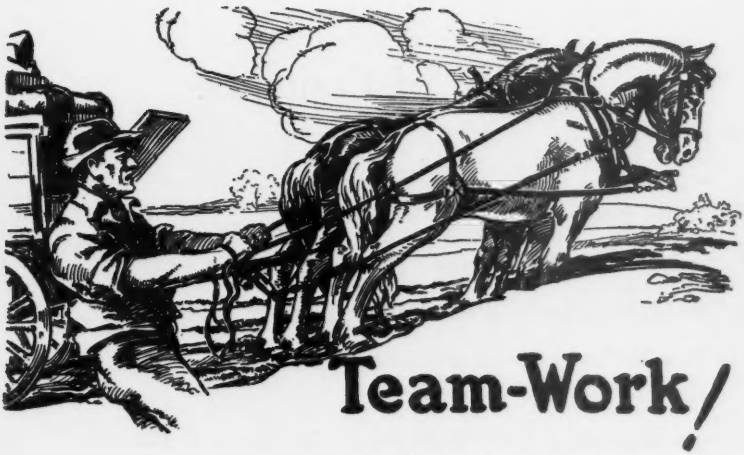
An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

Initiation Fees		*Annual Dues*	
Members	$ 3.00	Members	$ 6.00
Juniors	1.00	Juniors	3.00
Associates	10.00	Associates	20.00
Corporate Members	10.00	Corporate Members	10.00

This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.



Team-Work!

"See those two horses throw their weight and strength against the traces! Each does his full share. That's real team-work!"

AND so with Lock Joint Pipe lines. The steel and concrete in them work as a team in throwing their strength unitedly against the water pressure. And the joints give and take, expand and contract, to "take the load."

The team-work of the concrete and steel in our pipe lines is ideal, one always backing up the other. The steel insures great tensile strength and elasticity. The concrete makes a strong, dense wall, with remarkably smooth surfaces. It effectively protects the steel from corrosion and insures permanently-high carrying capacity.

There are many joints in a pipe line, but, in a Lock Joint pipe line, every one of them is a permanently-tight expansion joint.

Sewer
Pressure
Subaqueous

LOCK JOINT
Reinforced
Concrete Pipe

LOCK JOINT
PIPE CO.
14 Rutledge Ave.
Ampere, N. J.

Table of Contents.

PAGE

Portrait of President Arthur D. Weston ..... *Frontispiece*

Protection of Catchment Areas. By John F. Skinner 1

A New Kind of Pipe for Water Mains. By R. W. Mitchell 18

The New McTavish Pumping Station at Montreal, Que.
By Charles J. Des Baillets 32

Unusual Methods of Water Purification. By Martin E. Flentje ... 38

The Oxy-Acetylene Process in Modern Industry, with Particular Reference to the Piping Field. By R. W. Boggs 44

Average Rainfall Tables for Northern New England.
By Gragg Richards 50

The Gas-Producer Plant for Water Pumping at Manchester, Mass.
By Raymond C. Allen 56

Decolorization by Storage in Clean-Bottomed Reservoirs.
By Karl R. Kennison 60

Proceedings:

- November Meeting 76
- December Meeting 77
- January Meeting 78
- Report of the Committee on Cross-connections 79

Photo by Marshall.

ARTHUR D. WESTON,
President of the New England Water Works Association.
1928-1929.

New England Water Works Association

ORGANIZED 1882.

Vol. XLIII. March, 1929. No. 1.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

PROTECTION OF CATCHMENT AREAS.*

BY JOHN F. SKINNER.†

[*Read September 18, 1928.*]

It would be ideal to own a watershed and have available ample funds for policing, farming, lumbering and reforesting, road building and the maintenance of structures. An approximation to the benefits of such ownership within the means of the municipality is desirable and reasonable in so far as it conserves the purity of the water and its attractiveness from an esthetic standpoint. The value of taste and appearance in food is unquestionable. The same is true of water.

Our first thought in connection with watersheds should be *conservation*. We must conserve the water produced by the catchment areas both as to quantity and quality. To do this we must preserve natural conditions of forest and soil, cleanliness and sanitary conditions, and also beauty and a right public opinion; for if we are careful not to mar the landscape and not to make a point of excluding those who may enjoy its recreational aspects, we shall go far toward securing coöperation in maintaining the cleanliness that is so much to be desired. To this end the watershed may be made a sanctuary for wild life; unusual types and specimens of trees may be marked, as in a park; roads may be constructed to make the entire territory accessible; and recreational features may be stressed or at least allowed under proper regulations.

Type of Water Supply. When a water supply is derived from wells, less attention need be paid to the catchment area than in the case of surface water supplies. *Artesian wells* penetrating impervious rocks or clay may reach water-bearing sands that derive their water from distant sources, and the water will be naturally filtered. *Wells in limestone* that receive water through fissures are often polluted. A study of the geology of the region may disclose the origin of the water and in some cases protection of the catchment area may be valuable. *Shallow wells* sunk into water-bearing sand or gravel require protection in the immediate vicinity of the wells; the water from greater distances will be naturally filtered.

*Author's Note: The general subject of watershed protection is treated in Chapter III of the 1925 edition of the *Manual of Water-Works Practice*, published by the American Water Works Association, and this chapter has recently been discussed by E. Sherman Chase, in the Journal of that Association. *Jour. A. W. W. A.*, July, 1928, Vol. 20, p. 90.

†Sanitary Engineer, Department of Public Works, Rochester, N. Y.

When a supply is taken *from a large stream or lake* it will generally be economically inexpedient to attempt to protect the watershed; attention may better be devoted (1) to the location of the intake, to minimize local pollution and (2) to subsequent treatment of the water.

For *surface supplies* from sparsely inhabited upland areas, considerable attention may be paid to protective measures, and if the property is cheap, large areas may be purchased and controlled. Where storage is small so that chance contamination may reach the supply quickly, people should be excluded as thoroughly as possible from the watershed; if, on the other hand, there is long storage, the public may be admitted under proper regulations and restrictions, and the portion of the area farthest from the intake or diversion may be opened to campers, tourists and fishermen.

Type of Watershed. If the area is flat agricultural land with gentle slopes toward the main stream or lake, it may be sufficient to acquire a marginal strip of 100 yards or less along the shore of the lake or reservoir. In addition to this, highways within this line should, in general, be relocated farther back; outhouses, hogpens, barnyards and refuse dumps should be removed from the immediate banks of tributary streams; and garbage should be collected and treated or buried so that it will not reach the streams. The territory acquired should be policed and notices should be posted along the nearest highways, particularly at stream crossings.

If the area consists of steep, rugged land from which the water runs off rapidly, particular attention should be paid to villages and dwellings, to prevent crude sewage from washing into the reservoir. On such land, of course, there is likely to be the minimum of inhabitants, and the land will generally be cheap and readily purchasable.

If land is highly cultivated, it will have a larger human and animal population and consequently be more subject to contamination.

Paul S. Fox, in his paper "Watershed Sanitation,"* states that the New Mexico sanitary code empowers the governing body of a municipal corporation to exercise control over a watershed for a distance of 5 miles above the point of diversion. He also writes: "On the watershed . . . grazing was prohibited, which seems to be next to impossible. It was reduced, however, to a minimum and the improvement in the quality of the water, from a bacteriological viewpoint, was remarkable. The restriction of recreational uses under controlled conditions was effected by ordinances, posting and policing."

Villages. Small settlements on the immediate shores of reservoirs should be purchased and removed wherever possible. More remote villages and those too large and expensive to destroy must receive attention in other ways. Their wastes of all kinds must be excluded under the direction and at the expense of the authority or company constructing the water supply. In some cases contamination may be avoided by discouraging public sewers and by inspecting and cleaning middens at frequent intervals.

*Jour. A. W. W. A., July, 1928, Vol. 20, p. 50.

Especial attention must be given to vaults in the winter when the ground is frozen, for if vaults are too full at this season, their contents may overflow and reach the water during the first thaw. In some cases it may be necessary to construct a sewage disposal system to care for the sanitary sewage of the place. In all such cases a clear, well oxidized effluent should be produced and chlorinated.

Storm water passing through a village will necessarily carry impurities. Rough filtering or screening may be required, and care must be taken not to locate a water-works intake within the area of influence of such storm-water streams.

Cottages and Isolated Houses. It is best to purchase and remove cottages from the immediate shores of lakes or reservoirs. Pending such action, an efficient pail system is a palliative.

Use of Watersheds.

Certain portions of catchment areas which it may be advisable to purchase in order to control their uses and occupancy, and which can be profitably farmed, may be leased to agriculturists, giving first choice to former owners or occupants. Such rental should be subject to specified conditions under the constant and immediate control of the water-supply authorities or owners. This will mitigate in a large measure the opposition of some who do not wish to move from the locality preëmpted.

Reforesting. Without doubt, especially in rugged country, forests will afford the best cover for the catchment area of surface water supplies. Plantings along streams will assist in preventing erosion of the land as well as formation of bars and deltas in the reservoir and consequent loss of storage. It is well to maintain a bare strip a little above high water mark beyond which the littoral planting for possibly 100 yards or more in width may well be restricted to conifers, so that leaves of deciduous trees may not fall or blow into the water.

It has been suggested, when large tracts are to be reforested, that nut trees and berry-bearing shrubs be planted to furnish food for birds and other small wild life. Valuable woods, such as shell-bark hickory, white ash and black walnut, flourish in some localities.

Many articles on the preservation of forests have stressed the prevention of erosion, the minimizing of floods and the relative constancy and uniformity of run-off from forested as distinguished from denuded areas. These are all arguments for reforesting a catchment area and indicate that a wooded area will make a storage reservoir of given capacity more efficient by ironing out the irregularities of the supply curve. Such forests should be planted with reference to the exposure and soil conditions best fitted for various kinds and varieties of trees.

Lanes about 50 feet wide should be left clear as fire stops, and where possible these lanes should be so located that they may later be used as

roads in lumbering; for it may be anticipated that with the increasing scarcity of timber these trees will, in the years to come, produce a valuable commodity and a considerable income.

Roads. Good, serviceable roads should be provided to make the territory accessible, and if the public is to be admitted, the municipality may treat the area, in a measure, as a park and construct good roads, cutting vistas through the trees and running the roads to sightly lookouts where scenic effects are available. Wayside springs may be developed as drinking fountains for travelers.

Camp Sites. Camp sites may be established either for automobile tourists or for those who may wish to remain for longer periods at locations several miles from the point of diversion and limited by local conditions. These sites may be of various types, including parking spaces for those living in cars, tent sites and tent floors for those who bring canvas shelters, and forest cabins, more permanent in character, but in general housing a single party. Rustic comfort stations may be provided of the type used in the western parks by the U. S. Public Health Service.* At such camps, water supplies should be provided and means for handling garbage and refuse. The fees charged should be sufficient to maintain the service and properly police the camp.

Fishing. There has always been a difference of opinion on the safety and advisability of allowing fishing in a natural lake used as a reservoir. One position is that if fishermen are excluded from the lake and its shores, they cannot contaminate the water; hence they should be excluded and possible contamination avoided. Another position is that of nature lovers who enjoy the woods and streams and fishing, and who feel aggrieved at being excluded from their former haunts. They are sure that they have never harmed a lake, as they themselves drink freely from it when on excursions in the neighborhood. It is difficult to see how fishing on the upper 5 miles of a lake 15 miles long, where the water after two or three years' storage is diverted at the lower end, can injure in any way the quality of the supply, if proper sanitary measures are prescribed and enforced. The cost of service, maintenance, policing, etc., can be borne by small fees exacted for rentals, fishing permits, etc.

Hunting. Hunting should in no case be allowed. Government reports state that small game and game birds are being exterminated. The remedy is in providing sanctuaries where they may find food and remain unmolested. A large forested watershed incidentally provides such conditions while, at the same time, the absence of hunters reduces the fire hazard and makes the forest safer and more attractive to the great majority of visitors.

Bathing. On sanitary grounds only, it is probable that a limited amount of swimming in a lake or reservoir 10 or 15 miles away from the water-works intake would not appreciably injure the supply but, from

**Public Health Reports*, June 12, 1925, Vol. 40, No. 24, pp. 1248–1258.

esthetic considerations, bathing should be prohibited as most people are averse to drinking from another's bathtub. In this connection I am reminded of the defense made by a pickaninny who was caught swimming in the Washington Reservoir. He was asked what he meant by bathing in the water people drank. His answer was: "Boss, I ain't washin' in de drinkin' water. I's just swimmin'. I din't use no soap."

Public Opinion. The growth of cities and consequent need of public water supplies, and the increasing efforts of the population to escape into the country, coupled with the ready means of transportation now at hand, present a many-sided situation which calls for broad consideration and a reasonable coördination of the interests involved. A certain public service company's engineer favored the entire elimination of flow over a beautiful waterfall because, based upon the traffic over a bridge below the fall, he figured the wasted water was costing about five dollars a look. There are cases where an entire water power might be properly utilized; it would be difficult, however, to convince the public that any private franchise or public use of Niagara power should be allowed to destroy the scenic attraction of Niagara Falls. The same principle holds in a water-works property. The supply may be assumed as a public necessity. The creation of storage for compensation water to communities downstream and the protection of the catchment area should go hand in hand as a part of the cost of the proposition. It will usually require but a small additional expenditure to make the territory attractive and to afford pleasure to many people.

If the public, made up as it is of the individuals who eventually pay the bill, is shown consideration and afforded a beautiful forest retreat, is given distant views of the blue water reflecting sky and shore and a chance for a little fishing, a pride will develop in "Our Water Works." All will become boosters, and there will be the best possible coöperation in keeping the catchment area clean. Such organizations as the scenic societies, conservation associations and the Izaak Walton League include in their membership an active and intelligent portion of our population. Their wishes are to be considered, and they obtain publicity and make public opinion.

Rochester, N. Y. Watershed.

As an illustration of a well-managed watershed, a small portion of which has been purchased, we may refer to the present catchment area of the municipal water supply of Rochester, N. Y.

The total watershed now in use is 66.2 sq. miles of which 48 sq. miles are tributary to Hemlock Lake (Fig. 1), 12.4 sq. miles to Canadice Lake and 5.8 sq. miles to the Canadice Outlet. Canadice Lake lies nearly 200 ft. higher than Hemlock Lake, and the outlet is a tumbling stream running through a quick watershed to the Hemlock Outlet. From a low diversion dam in the Canadice Outlet Channel, a 60-in. concrete conduit brings the

FIG. 1. — SOUTH END OF HEMLOCK LAKE (HEAD) SHOWING PRESENT NATURAL FOREST COVER, 1927. — ROCHESTER WATER SUPPLY.

Canadice water into Hemlock Lake from which the present conduits proceed to the city of Rochester about 390 ft. nearer sea level and 27 miles due north.

Hemlock Lake had a natural shore line about 15 miles long. For about 20 years but little land was purchased and the cottages along the shore were served by a pail-privy system operated by the city. In 1895–1896, a strip 200 ft. wide from high water mark was purchased, and other lands have been added from time to time. Last year the dike across the foot of the lake was raised 5 ft. to furnish increased storage, and considerable property at the head of the lake was flooded during high water. The total area owned by the city around and on the watershed of Hemlock Lake is 2 617 acres. (Fig. 2.)

On February 6, 1919, water was turned into Hemlock Lake from Canadice Lake. The land acquired in the Canadice Lake watershed amounts to 550 acres, and 350 acres have also been purchased in the Canadice Outlet, making a total of 3 517 acres now owned on the catchment area. Patrol of the shores is maintained, and the washing of sheep in the lakes, as formerly practised, has been discontinued. Where formerly barnyards and heaps of waste were located on the banks of runs and ravines, buildings have been constructed elsewhere, partially at the city's expense and the unsanitary conditions thus abated. By closing a road along the east shore of Hemlock Lake, a potential source of pollution was removed. This was made possible by the coöperation of the local highway commissioner who had found this road difficult and expensive to maintain. When the cottages were removed there was no reason for the road, as it was paralleled by another and better road on higher ground.

About 25 years ago an inspection of the Hemlock Lake Watershed was made, and also a census of people and animals. An index map (Fig. 3) and sectional maps (Figs. 4, 5) covering the entire territory were prepared from the county atlases and were used in this and subsequent inspections. In the late eighties there had been an epidemic of typhoid in the village of Springwater, three miles above the head of Hemlock Lake. No typhoid, however, appeared in Rochester.

Canadice water has always been chlorinated before its discharge into Hemlock Lake, and since May 11, 1925, the entire supply from the domestic system has been chlorinated at Rush Reservoir, nine miles from the city. Taste or odor due to chlorination is not noticed in the water, as the conduits discharge into two distributing reservoirs of a total capacity of 165 million gal. where there is at present over five days' exposure to the air. There is a large fountain in each reservoir through which about 25 m.g.d. pass during warm weather.

The city property at the foot of Hemlock Lake near the gatehouses is landscaped, and a picnic pavilion is available with a grill upon which meat may be broiled. There is, of course, ample water supply, and comfort stations and parking space are provided. In addition to small parties and some organizations from the city, the place is frequented by organizations

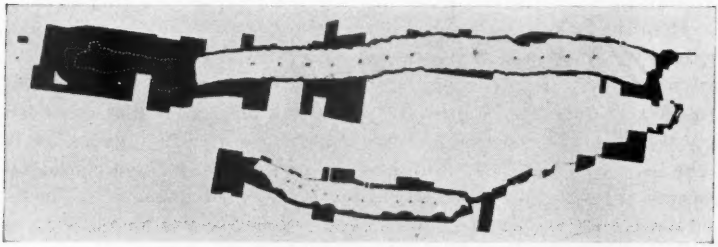


FIG. 2. — PROPERTY ACQUIRED AROUND HEMLOCK AND CANADICE LAKES. — ROCHESTER WATER SUPPLY.

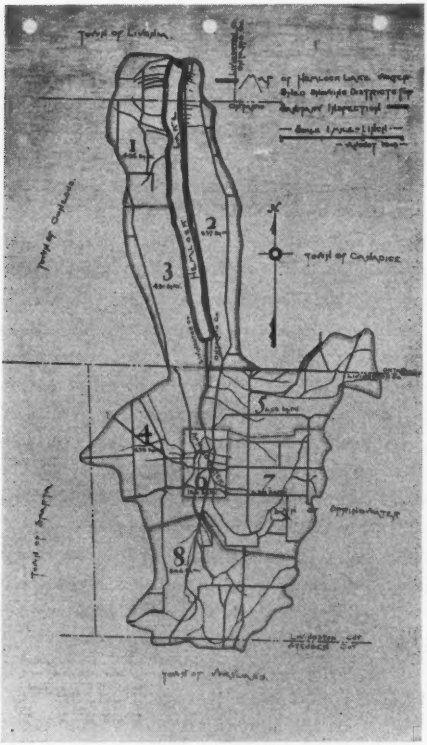


FIG. 3. — INDEX OF SECTIONAL MAPS USED IN INSPECTION OF WATERSHED.— ROCHESTER WATER SUPPLY.

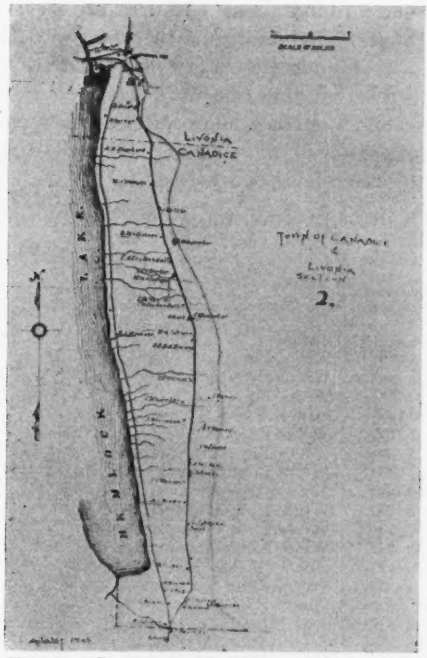


FIG. 4. — SECTIONAL MAP USED IN INSPECTION OF WATERSHED. — ROCHESTER WATER SUPPLY.

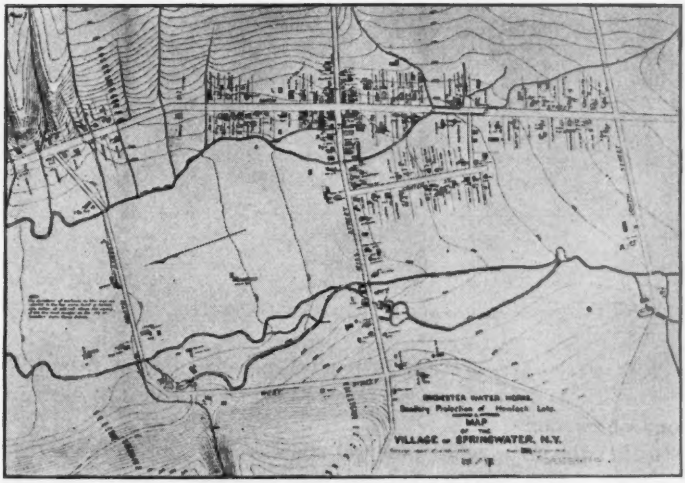


FIG. 5. — MAP OF VILLAGE OF SPRINGWATER, N. Y., USED IN INSPECTION OF WATER SUPPLY. — ROCHESTER WATER SUPPLY.

from the rural country round about. Its free use serves to create good feeling between the local inhabitants and the water-works authorities.

In 1902 the city of Rochester began planting trees on the shores of Hemlock Lake. Since that time the work has been extended along the shores of Hemlock and Canadice lakes and on other areas acquired on the immediate watersheds of these lakes. The following table exhibits the number and varieties planted each year:

REFORESTING OF WATERSHEDS.
Hemlock and Canadice lakes.

Year.	No.	Kind.	Total.
1902	8 700	Spruce	
	4 300	White Pine	13 000
1903	10 000	White Pine	10 000
1909	20 000	White Pine	20 000
1910	10 000	Scotch Pine	
	1 000	White Pine	11 000
1911	13 000	White Pine Transplants	
	17 000	White Pine Seedlings	
	30 000	Norway Spruce	60 000
1912	62 000	White Pine Transplants (3 yrs.)	62 000
1913	71 000	White Pine Transplants	71 000
1914	30 000	White Pine Transplants (3 yrs.)	
	30 000	Red Pine Transplants (3 yrs.)	
	25 000	Scotch Pine Seedlings (2 yrs.)	85 000
1915	125 000	White Pine (4 yrs.)	
	50 000	Red Pine (3 yrs.)	
	76 000	Scotch Pine (3 yrs.)	251 000
1916	100 000	White Pine (3 and 4 yrs.)	100 000
1917	100 000	Red Pine (3 and 4 yrs.)	100 000
1918	30 000	Red Pine	30 000
1919	12 000	Red Pine Transplants (3 yrs.)	12 000
1921	50 000	Scotch Pine (3 yrs.)	50 000
1922	50 000	Norway Spruce (2 yrs.)	50 000
1923	50 000	White Pine Transplants (3 yrs.)	
	50 000	Red Pine Seedlings (2 yrs.)	100 000
1924	25 000	White Spruce Transplants	
	25 000	Scotch Pine Seedlings (2 yrs.)	50 000
1925	50 000	Scotch Pine Transplants (3 yrs.)	50 000
1926	100 000	Scotch Pine Transplants (3 yrs.)	100 000
1927	100 000	Scotch Pine Transplants (3 yrs.)	100 000
1928	90 000	Red Pine Transplants (3 yrs.)	
	10 000	Norway Spruce Transplants (3 yrs.)	100 000
		Total number set	1 425 000

The reforested stands of nearly 1 500 000 trees cover about 1 250 acres.

Work was begun in 1902 with pines purchased from Brown Bros., Rochester, N. Y. Since 1902 all trees have been furnished by the Conservation Commission.

In 1917 the use of white pine was abandoned — due to the prevalence of "blister." This difficulty has now been removed.

Proposed Additional Watershed. A project for increasing the water

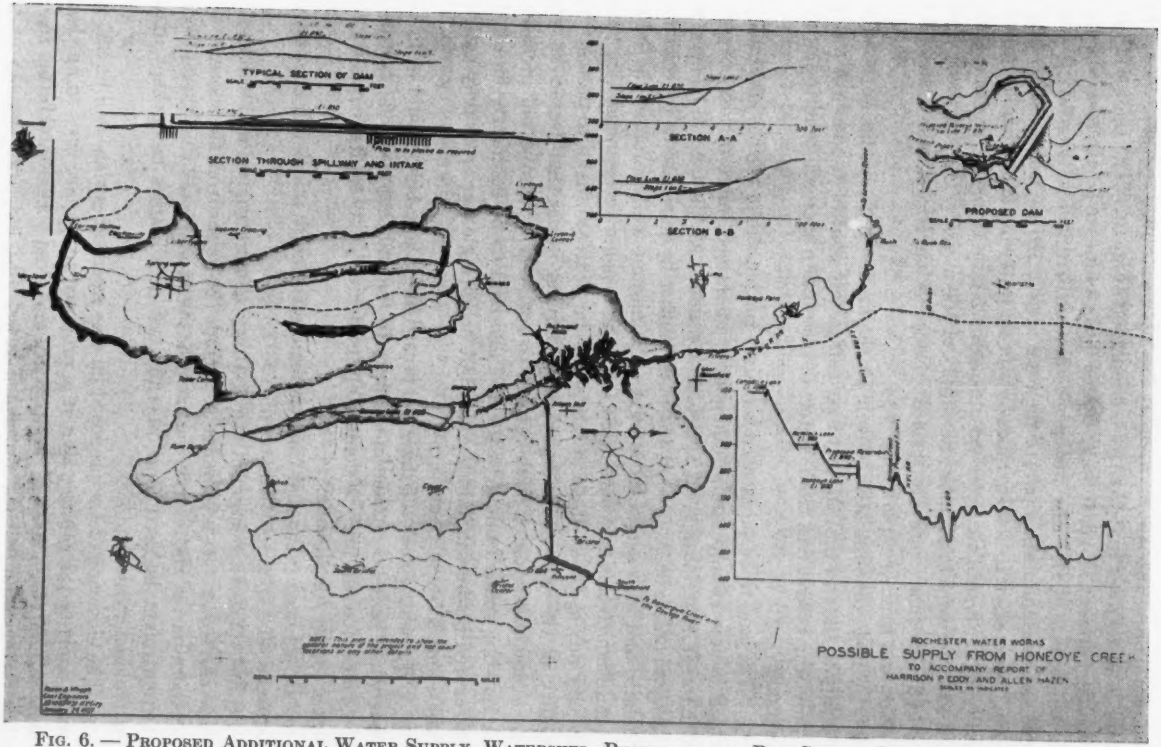


FIG. 6. — PROPOSED ADDITIONAL WATER SUPPLY, WATERSHED, RESERVOIR AND DAM SITE. — ROCHESTER WATER SUPPLY.

supply by a large addition to the present watershed through the construction of a dam in the Honeoye Valley has been approved by the New York State Water Power and Control Commission (Fig. 6). The plan will increase the present Honeoye Lake from 4.5 to 15 miles in length and raise its normal surface 30 ft. The watersheds now utilized will be tributary to the new reservoir and form a part of the total area of 187 sq. miles. This may again be increased to 209 sq. miles by storing water in a high parallel valley and bringing it into the reservoir through a 5-mile tunnel. The new project looks forward to an ultimate supply of 100 m.g.d. The engineers who devised this plan were Harrison P. Eddy, Allen Hazen and Edwin A. Fisher, and in their report they say:

"A large amount of land will be required. This should be bought liberally to the end that the city may completely control its source of water supply, and hold it free from centers of population that will tend to impair its quality.

"The land to be submerged is mainly the bottom of the old lake valley which is now swamp land, uninhabited, undrained, more or less covered with forest, and not of great agricultural value. All the land to be flooded must, of course, be secured at the outset either by purchase or by eminent domain, and also a certain margin of minimum width around the lake. In addition to this, and somewhat optional, it is our recommendation that the city buy as far as it can at fair prices, large areas of land to protect the quality of the water. In some cases, buying farms that would be left inconveniently situated with respect to roads, will remove the necessity for building roads leading to them. The land to be submerged must all be secured before the dam is built, but acquiring other areas may extend over a long series of years.

"We believe that the marginal areas bought and held should be much wider than have been taken in the past, to the end that the great new lake to be now formed may be completely protected in its sanitary quality for water supply for all time."

It has been estimated that the land eventually taken will amount to between 30 000 and 40 000 acres.

The southern portion of the territory is more rugged and excellently suited for forest. It is proposed to exclude the public from the shores of the northern part of the reservoir, while it has been suggested that the southern portion might be used more liberally but at all times being kept under careful supervision.

The elevation of the proposed lake or reservoir surface will be 830 ft., while some of the country that it is proposed to acquire rises to an elevation of 2 200 ft. Beautiful views may be had from present and future roads. The farthest limit of the watershed is but 40 miles from the city as the aëroplane flies, and the round trip by highway from Rochester around the reservoir may be accomplished through 90 miles of varied scenery in a few hours.

Aërial Map. For the purchase of so large an area and because of the difficulty and expense of surveying such rough and wooded country and mapping it in the usual way, an aërial survey and photographic map were decided upon. There were made 529 original 8 in. x 10 in. negatives on a scale of about 1 000 ft. per in. flying at 12 000 ft. elevation. These pictures will be "laid" and the map enlarged to a scale of 800 ft. per in. Greater enlargements may be made of any details up to 100 ft. per in. The weather was very uncertain; some re-flying was necessary on account of clouds, and it required from May to August, with the plane constantly ready for flight, to accomplish the few hours of photography required for the 205 sq. miles of area covered. In order to give scale to the map, the city has undertaken a first order triangulation survey of the territory, and has placed a series of visible ground marks at known locations on both high and low ground. In the pictures, lot lines described in property conveyances are readily identifiable and a net consisting of these lot lines will be superimposed on the photographic map.

In this region a run, ravine, arroya or gully is colloquially known as a "gull." These gulls generally reveal themselves in the pictures as broad crooked lines of trees and shrubs. Forests have a mottled appearance due to tall and low trees while nurseries or plantings of our reforesting show a plane and uniform color due to the trees in the given area being of the same age. As the views are taken vertically, they make a map rather than a picture and can therefore be used in fire observation towers or wherever a map of small scale would be useful. In addition features are shown in a detail rarely attained in mapping from surveys.

Conclusion. In the protection of catchment areas, we should have a *true* map to show things *honestly* as they are. The treatment of the public in reference to the area should be *just* from every viewpoint. The water should be kept *pure* and the surroundings *lovely* as in nature. This will result in *good reports* of the system so that any *virtue* in the management will receive the *praise* deserved. I would leave *these thoughts* with you. They can be aptly stated in the words of the Apostle:

"Finally, brethren, whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report; if there be any virtue and if there be any praise, think on these things."

Discussion.

Arthur D. Weston.* In the State of Massachusetts the acquiring of any large body of water for public water supply purposes is, of course, done by an act of the legislature. Any pond over ten acres in size in Massachusetts constitutes a great pond and the public has certain rights on a

*Massachusetts State Department of Health, Boston, Mass.

great pond. In order to utilize these ponds or lakes for water supply purposes, an enabling act is secured from the legislature. I have always felt that if municipalities obtain the use of lakes or ponds by legislative act for water supply purposes, the legislature meant just that, — it did not mean that lakes and ponds were to be thus acquired and later on utilized for recreation, — fishing, and so forth.

The General Laws provide for the establishment of rules and regulations by the Department of Public Health for the purpose of preventing pollution of lakes, ponds, streams, etc., used as a source of public water supply. The question of the advisability of permitting fishing on sources of water supply has been considered many times, and rather an interesting phase of this subject appeared last spring. It seems that many fishing associations were desirous of having the right granted their members to fish on the reservoirs and lakes used for water supply purposes, and they interested the Department of Conservation in seining the fish from reservoirs and placing them in other great ponds that were not used for water supply purposes. Rather an interesting point was thus brought up; should the municipal authorities exclude the public from fishing on a reservoir and yet authorize a crew of men to catch the fish on behalf of the state? A meeting was held in the State House and water commissioners from different parts of the state were invited to come and express their views on this subject. As a result, it was decided that the matter be left entirely with the local authorities in granting permission to the Department of Conservation to fish from their reservoirs, but only if the State Department of Public Health thought it was safe to do so. If the source of supply was a small reservoir and if there was a possibility of contamination of the supply near the intake, fishing would probably be forbidden.

I have always felt, in regard to boating and fishing, that it was practically impossible to limit the public to one section of a lake. Too great reliance should not be placed on the amount of water in storage as a factor against pollution. The storage factor is out of the picture, if pollution takes place near the intake. There have been occasions when a water supply was polluted near the intake.

In one municipality 1 500 cases of enteritis appeared after permits were granted to fish on a lake used as a source of water supply. The fishermen in this instance discovered an old crib that was formerly used as an intake to the pumping station and was within 40 or 50 feet of the existing intake. They found excellent fishing inside of the crib, especially at night. It was a nuisance to go to the shore while they were fishing, so they did not bother, and the reservoir became polluted.

Caleb M. Saville.* At Hartford we have objected to fishing on the reservoirs at all times, and also have prevented hunting so far as we could on the watershed areas. We have, however, done what Mr. Weston has spoken of, — that is allowed — the State Fish and Game Commission to

*Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.

seine the reservoirs, with the thought that if we got all the fish out the people would not be so anxious to come and fish in them.

I think there is usually a great deal of misunderstanding about the quantity of fish that are in reservoirs. You would think, to hear people talk about some of the Hartford reservoirs, that one could almost walk across on the backs of the fish. However, in one reservoir that I have particular knowledge of, the Fish and Game Commission placed five seines; kept them there for some weeks and only got a very few fish during the whole period.

Personally I think it is a very good thing to keep the public absolutely away from the water supply grounds. If I had my way I would put a ten-foot fence with barbed wire top around the whole watershed and keep the public out.

STEPHEN H. TAYLOR.* I think Mr. Skinner's points are all very well taken, with the possible exception of allowing some people to boat and fish while keeping others away from a publicly owned water supply. We find that if you open the gates to only one, the rest will want to know why they can't come on too. It creates a lot of trouble. We have, therefore, gone to the extreme of keeping everybody off. This, I think, is the safe way and the only way to keep peace in the community.

We fully believe in reforestation and are carrying on a great deal of it at New Bedford, with very good results.

Regarding the seining, we have had our ponds seined by the State Department of Conservation, and as in Mr. Saville's experience they were quite disappointed in the number of fish they got. Everybody thought our ponds were full of fish and that they were going to get millions, but the results showed only a few hundred fish after several days trapping with five or six nets. I believe, on the other hand, that at Fall River a great number of fish was found in the ponds.

We have taken up the question of creating a game sanctuary on our watershed, with the coöperation of a local fish and game club, and I think that it is really going to be productive of good results. Such action gets the good will of the sportsman, and by posting the game sanctuary sign alongside of our "No Trespass" sign, the public feels better about being kept off since they see that the property is being put to good use.

MR. SAVILLE. For some years now, the whole Hartford watershed, an estimated area of 5 000 or 6 000 acres, has been made a game sanctuary. This land is posted and no hunting or fishing is allowed on it, and no fires, on account of danger from forest fires. I think it is a very good thing, because it gives a place where wild life can increase, and go forth to other areas where it may be possible for sportsmen to use it.

J. WALTER ACKERMANN.† We have been speaking about keeping people off our watershed area. Suppose, however, that a watershed

*Superintendent of Water Works, New Bedford, Mass.
†City Manager, Watertown, N. Y.

extends over 200 or 300 sq. miles. This situation, of course, has been covered in a way by the State Department of Health of New York by establishing certain zones, but it remains difficult to know when one is tramping from one zone into the next one. I quite agree that where it is possible to keep people off the catchment area it is a very desirable thing, but there are many places where this is entirely beyond the capacity of the municipality because of the size. I am referring in particular to the natural lakes in central New York. There we have to submit, perhaps, to fishing and to bathing, even.

EARL DEVENDORF.* As suggested by Mr. Ackermann, I think we have long since passed the stage in New York State in a number of the public water supplies taking water from large lakes or bodies of water where it would be possible for the municipalities owning the supply to undertake the owning of a major portion of the watershed. As Mr. Ackermann aptly suggests, the expense would be exorbitant. In the case of those municipalities obtaining their water supplies from sources having large watersheds, it has been our experience that reasonably satisfactory control of the sanitary conditions on the watershed can be maintained through the employment of a sanitary inspector, particularly during the summer months. The employment of such an inspector has resulted in the improvement of sanitary conditions on the watershed as, by the closer contact afforded with the cottage owners, they have been educated with reference to the importance and need of preventing pollution of the lake. As most of the cottage owners take water from the lake for household uses, we have endeavored to impress upon them that it is of as much importance for them to prevent pollution of the lake as for the municipalities whose water supply intakes are located much farther out from the shore, away from any possible shore pollution, and are furthermore generally treated either by filtration or chlorination, or both. In some instances cottage owners' associations have been formed, one of the primary objects of which is the protection of the lake from contamination.

Mr. Skinner (author's closure). There should be no discrimination as to what persons are admitted to water-works property; their actions, however, should be controlled. Mr. Taylor's practice of posting the "Sanctuary" sign along with other notices suggests itself as the normal procedure.

The reservoir proposed for Rochester will have an area of 8 000 acres at the overflow level. Manifestly different treatment may be applicable from that required for a 10-acre pond. With a watershed 25 miles long from which the public cannot be excluded, tributary to a narrow lake 15 miles long surrounded by a purchased area a mile or more wide, it may be easier to exclude visitors from the five mile length of territory near the water-works intake and admit them to the remainder of the area under restrictions than to attempt to exclude them from the lake altogether.

It is appreciated that water-works men who have done such splendid

*New York State Department of Health, Albany, N. Y.

work in providing the public with safe supplies have generally felt safer in keeping out pollution at the source, even when subsequent treatment is employed.

The purchase of very large property protection is relatively recent and this, combined with the methods of purification available and the growing desire for recreational facilities, must lead us to take into consideration all points of view.

A NEW KIND OF PIPE FOR WATER MAINS.

BY R. W. MITCHELL.*

[*Read September 20, 1928.*

It is axiomatic that the function of the engineer is to determine, with the information at his disposal, the economic relationship between first cost and efficiency of the materials that he proposes to use in an engineering project. The best construction is that which combines economy and efficiency. In water-works design — especially in gravity supplies — the main supply-line is of major importance, and its cost in relation to subsidiary works often represents the major portion of the total expenditure. It is not surprising then that a great deal of time and study has been expended in an endeavor to secure a pipe at once cheap, strong and of good hydraulic characteristics. All the pipes at present on the market have their limitations in one respect or another, but by a judicious selection of those at his disposal, the water-works engineer has so far been able to meet conditions as they have arisen.

It is not proposed to make comparisons as to the relative merits of the various pipes available, but to record the latest development in concrete pipe manufacture and use.

Pipes. The increasing use of concrete as a building material and its deserving popularity have been reflected in the developments in concrete-pipe construction. Numerous water mains have been built of reinforced concrete pipe — both on the American continent and in Europe — but its field for pressure work has been very definitely limited by its incapacity to remain water-tight when the pressure exceeds about 150 ft.; this figure is approximate only and varies with the diameter of the pipe under consideration. We shall pass over what is known as poured concrete pipe, or hand-cast concrete pipe, since it is admitted that centrifugally-cast concrete pipe is unquestionably superior. Starting then with a centrifugally-cast reinforced concrete pipe as a *fait accompli*, let us see wherein its field is limited by its own characteristics.

The application of centrifugal force to the compacting of the walls of a concrete pipe is not an unmixed blessing. By its very action, while a dense wall is produced, the uniformity of the structure is destroyed, as the heaviest particles of the aggregate are forced to the outside of the shell and the lighter particles, together with a large proportion of cement, remain on the inside. The compacting action of the centrifugal force displaces the surplus water in the mix; the water finds its way to the inside of the spinning shell and brings with it some of the fines in the aggregate; these, in the form

*Consulting Engineer, Asphalto-Concrete Corporation, New York, N. Y.

of *laitance*, are distributed, together with any light materials, on the inside of the pipe. The resulting finish is poor, and many methods have been employed to overcome this objectionable feature; some of these methods have been very successful, others only moderately so.

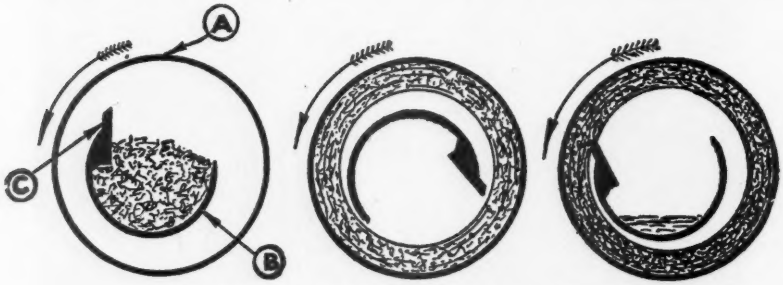
The centrifugal process, which is to be described briefly, was evolved for the purpose (1) of overcoming the segregation of the aggregate, and (2) of quickly and certainly removing the objectionable *laitance* from the inside of the pipe and definitely controlling the diameter.

FIG. 1. — 18- TO 30-IN. MOIR-BUCHANAN CENTRIFUGAL MACHINE FOR MAKING CONCRETE PIPE.

The principles involved are simple. The rate of spinning is controlled so that, while a moderate compacting effect is produced by centrifuging, the rate of rotation is not sufficiently high to separate the aggregate. The charge is uniformly distributed along the whole length of the pipe and the mix used is relatively dry, so as to minimize the amount of water to be removed and, consequently, to minimize the amount of cement and *laitance* brought to the inside of the pipe. The required density is produced mechanically by means of a combination knife and trowel that compacts the concrete and trims it to dimension.

The machine used is essentially a lathe (Fig. 1) by means of which the mold (A) is driven against the action of the trowel or knife (see Fig. 2). The concrete is deposited by means of a bucket (B), roughly semi-circular in section and of the same length as the pipe to be cast, which is mounted on a rolling carriage operating between guides. This bucket carries, at one side of the opening, a steel blade or knife (C) which extends the full length of the pipe and with which the necessary cutting and trowelling is effected. The bucket is overhung from the carriage and mounted on a revolving mechan-

ism with its axis eccentric and parallel to the longitudinal axis of the mold so that, when carrying and dumping (see Fig. 3), it is quite clear of the mold and the material dumped and, when turned in the opposite direction to that of dumping, the blade is brought into contact with the concrete dumped, and trowelling is effected (see Fig. 4). Two charges of the bucket are required to form a shell. The quantity of concrete put into the bucket is not measured, since any excess material is cut off by the blade and drops back into the bucket, together with the surplus water and objectionable *laitance*, which are removed. An indicating dial, along which a pointer moves, indicates the exact position of the knife and is graduated to represent



FIGS. 2, 3 AND 4. — ACTION OF BUCKET AND KNIFE.

eighths of an inch in the thickness of the shell. The accuracy to which the shell can be built up with the aid of such an indicator is obvious.

Trowelling may be performed at any desired position in the shell of the pipe so that the wall may be built up in a series of layers or laminations. The trowelling of the surface of each of these layers forms a fine, impervious skin and compacts the concrete in the layer against the wall of the mold, or the previous layer. The shell of the pipe so formed presents the appearance, in cross section, of a series of annular rings, each of which acts as a water stop or water-resisting medium. (Fig. 5.) There is, theoretically, no limit to the number of rings that can be formed; the choice is controlled by the exigencies of manufacture, the size of the aggregate and the requirements of the purchaser. The interior bore of the pipe is straight, smooth and true to dimension, so that, when laid, a perfectly straight and uniform pipe line is assured.

It may be said that the interposition of secondary water-tight surfaces in the shell of the pipe is redundant, since it is the barrel of the pipe that, as a rule, gives the least trouble. This is only partly correct, however. No matter how impervious the interior skin of a pipe, the ends are relatively porous, and it is at the joint that absorption occurs, which gradually spreads along the shell and appears in the form of pinhole weeps. With annular water stops, however, it is possible to so place the jointing material in the

shell of the pipe as to permit of the rings extending beyond it, and so preventing the water from leaking around and to the outside. (Fig. 5.)

Concrete water pipes, made by the centrifugal process described, represent the last word in high class manufacture but, while they increase the field of usefulness of reinforced concrete pipe, they have their limitations as to their pressure-resisting qualities. These limitations are inherent and are dependent upon the relative elasticity of the concrete and steel. A concrete shell can be reinforced in such a way as to withstand practically any pressure and remain structurally sound, but it will not remain water-

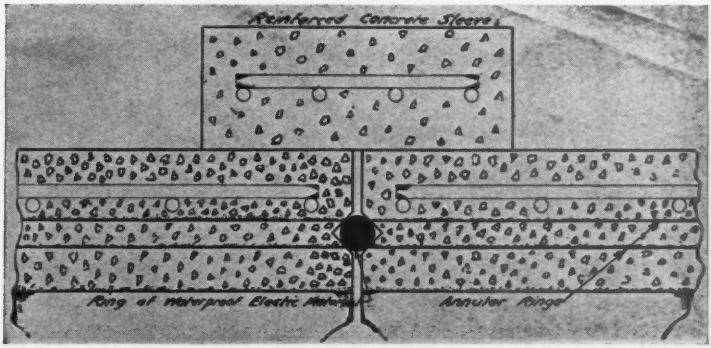


FIG. 5. — CROSS SECTION OF JOINT SHOWING POSITION OF JOINTING RING IN RELATION TO ANNULAR RINGS IN SHELL OF PIPE.

tight, owing to the fact that, long before the yield point of the steel is reached, the shell will have cracked and relatively large leakage will have taken place. Furthermore, remembering our original premise that efficiency must be combined with economy, the economic limit of usefulness of a reinforced concrete pipe is reached when the proportion of steel becomes too high; in other words, when it is necessary to go to a steel tube protected in some fashion or other.

Recognizing this limitation, several attempts have been made to overcome it, either by waterproofing the concrete by means of an integral waterproofing medium, or by a waterproof skin applied to the interior. In all of these attempts, first principles were ignored, namely, that the elasticity of the concrete itself is the controlling factor. No matter how waterproof the structure is in itself, it obviously cannot remain an impervious water-carrying medium, if cracked. Asphalt applied to the inside of a pipe was the nearest approach to recognition of this principle, but there again the antipathy of asphalt to concrete was not fully allowed for, with the result that the asphalt coating could be easily removed and very soon perished by being actually washed out of the pipe.

Asphalt as a waterproofing medium has been recognized throughout the ages, and fragments of the old Babylon Aqueduct, waterproofed with

asphalt, are still in a state of good preservation today. Given then such an ideal medium, the problem of its application was susceptible of solution. The most efficient solution to date, the author believes, is that used in the following process.

It was found that clean stones, heated to a predetermined temperature, would fuse into and bond positively with an asphaltic concrete mixture. The bond obtainable between stones and concrete is obvious. With this bonding medium, the application was only a matter of experiment. The process now actually in use commercially, is simply an extension of the centrifugal process of manufacturing the concrete shell.

FIG. 6.—THIRTY-TWO-IN. PIPE SHOWING BONDING STONES IMBEDDED IN INTERIOR OF THE CONCRETE SHELL.

Instead of finishing off the shell to a smooth bore, a charge of stones or coke, broken to uniform size, together with a proportion of cement grout, is added and spun in. The centrifugal action imbeds the stones securely in the grout which is of sufficient thickness to cover them to about half their depth. The pipe is then thoroughly cured in the ordinary way, and the protruding ends of the stones are thoroughly cleaned of all *laitance* and foreign matter. (Fig. 6.)

The shell with its rough stone interior is then placed in a mold of sufficient length to leave a space between the ends of the pipe and the mold; the pipe being held in position by means of rubber bands that act as cushions. The stones are then heated by means of a hot-air blast to a predetermined temperature.

A sufficient quantity of molten asphalt to give the required thickness of lining, usually about $\frac{1}{2}$ in., is added, and the pipe is spun on a simple spinning machine to uniformly distribute and compact the lining.

Spinning is continued until the asphalt has practically set, when cold water is run in to accelerate the rate of cooling. The water has the double effect of cooling and polishing the asphalt which, upon the completion of

the process, presents a hard, smooth, mirror-like surface. (Fig. 7.) On first thought, this would seem rather a laborious and long operation, but it must be borne in mind that the materials entering into the construction are all simple, and that the labor is not a costly item.

Let us now examine the asphalt-lined, waterproofed pipe manufactured in conjunction with the centrifugal method of making the concrete

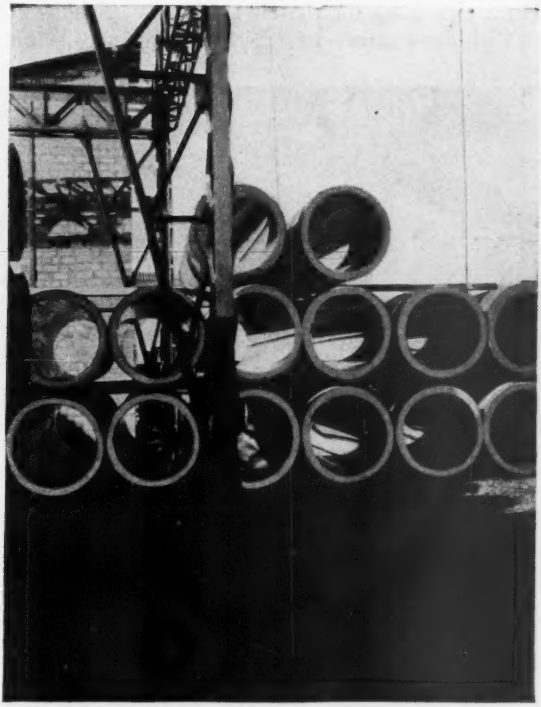


FIG. 7. — PIPES SHOWING HIGHLY GLAZED ASPHALT LINING.

shell. We have here a concrete of the greatest possible density, that is,— so far as we have progressed — protected by a thick, elastic and stable asphalt coating, securely bonded to the concrete and acting with it. When I speak of asphalt, I do not mean asphaltum, or bitumen, a soft and relatively viscous material, but a stable, hard asphaltic concrete that of itself has considerable tensile and crushing strength. The elasticity of the asphalt lining is greatly in excess of that of the concrete shell, so that it can be expanded considerably without rupture. With this fact established, it is now possible to construct a structurally strong, reinforced concrete shell, making for the most efficient economic use of the combination of concrete and steel, waterproofed by an impervious elastic skin that ef-

fectually seals any minute cracks that may appear in the concrete under high stress. This is a tall statement to make, but it can be backed by actual tests. Two outstanding tests will be cited.

The process is French, and the French company that developed it has gone to great pains to have tests carried out by competent authorities, with the result that a line has been laid for the city of Bordeaux, which is giving every satisfaction, with absolutely no leakage, and a contract has been taken for a pipe main for the city of Paris. Needless to say, the authorities in both cases satisfied themselves completely before awarding

FIG. 8. — THIRTY-TWO-IN. ASPHALT-LINED PRESSURE PIPES, BORDEAUX, FRANCE.

the contracts. The Bordeaux line, which is 800 mm. (31½ in.) in diameter, was designed for a pressure of 100 lb. per sq. in. (Fig. 8.) Its characteristics are as follows:

Thickness of concrete shell..... 2½ in.
Thickness of asphalt..... ½ in.
Steel reinforcement per foot, 21 spirals of No. 8 gage, and 12 longitudinals of No. 6 gage, securely tied to the spirals.

In accordance with the formula used in calculating the steel reinforcement specified above, the steel will be stressed to 64 000 lb. per sq. in. at a pressure of 115 lb., and should rupture at a pressure of about 265 lb. per sq. in. Tests were carried out in a hydraulic testing machine on two pipes jointed together, the ends being attached to the machine by means of a flexible joint, permitting lateral and longitudinal movement. During the progress of the tests, readings were taken of the increase in circumference of the pipe; these are of interest. The pressure was raised progressively from 0 to 265 lb. per sq. in., with no appearance of leaking or sweating whatsoever — as shown by the following table.

Time, min.	Pressure lb. per sq. in.	Water Tightness.	Increase in Circumference of Pipe, mm.	Increase in Circumference of Joint, mm.
0	0–73	Neither leak nor sweating.	0	0
15	73	Neither leak nor sweating.	0.3	0
15	73–147	Neither leak nor sweating.	0.3–1.6	0–1.2
15	147	Neither leak nor sweating.	1.6	1.2
15	147–176	Neither leak nor sweating.	1.6–2.8	1.2–1.5
10	176	Neither leak nor sweating.	2.8	1.5
10	176–222	Neither leak nor sweating.	2.8–4.6	1.5–2.1
5	222	Neither leak nor sweating.	4.6	2.1
5	222–265	Neither leak nor sweating.	4.6–5.3	2.1–3.5
Ruptured at 265		Neither leak nor sweating before the rupture.	5.3	3.5

Pipes of varying diameters have been tested up to the limit of capacity of the testing machine at Fumel, France, namely, 540 lb. per sq. in. In every case, though the concrete shell cracked when the limit of its resistance was reached, the asphalt lining remained intact and preserved the complete water-tightness of the unit.

In order to see just how far this combination of asphalt and concrete might be carried in the way of pressure work, a 10-in. pipe, with an asphalt lining of $\frac{5}{16}$ in., was tested at the *Laboratoire d'essais du Conservatoire des Arts & Métiers** up to a pressure of 4 260 lb. per sq. in. This process of manufacturing concrete pipe for high-pressure work, economically and with high hydraulic characteristics, is, of course, quite new. So far, the only line in actual operation, with the exception of extensive test lines that have been built, is that just mentioned for the city of Bordeaux, which is some 7 000 ft. long.

Joints. A great deal of discussion has revolved around the proper type of joint to use in conjunction with concrete pipe and the relative amount of expansion and contraction that has to be allowed for. Undoubtedly, a certain amount of movement does take place, but it is relatively small and does not justify over-elaboration of the joint.

To be consistent, the joint of a pipe ought to be in conformity with the pipe itself, which is tantamount to saying that when dealing with a concrete pipe the joint should be preferably of concrete, or as nearly so as practicable. Numerous joints have been developed for the asphalt-lined pipes — some of them elaborate, some very simple. After a considerable number of tests had been made, the simplest joint proved the most efficient and, of course, the cheapest — a combination that is highly desirable.

The type of joint used, and now standardized, is made up as follows: A centering jack is used in laying. This jack is in the nature of an expandable split ring, extended in the same manner as an umbrella is opened. The ring carries, on its outside, a rubber ring that is protected by brown

**Report No. 38637.*

paper to prevent the asphalt from reaching the rubber. The ends of the pipes are bevelled and, before being brought into juxtaposition, are heated to slightly melt the asphalt. A steel band is then placed around the outer periphery of the pipes to seal the outside of the joint, and the annular space is filled with hot asphalt forced in under pressure. (Fig. 9.)

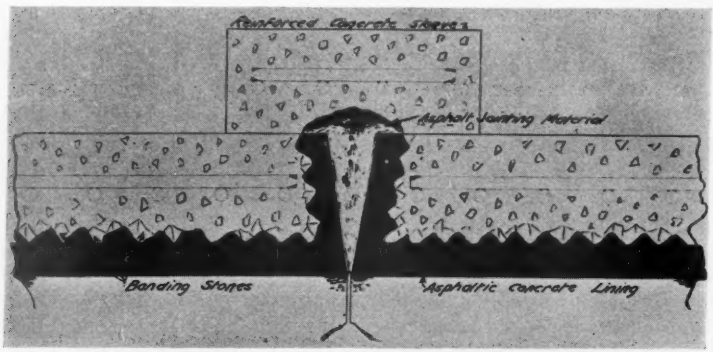


FIG. 9. — STANDARD JOINT FOR ASPHALT-LINED CONCRETE PIPES.

When the asphalt is cooled, the steel band is removed and a ring of steel reinforcement, previously threaded onto the pipes is brought over the joint and centered in a mold into which concrete is poured, forming a reinforced concrete sleeve around the joint.

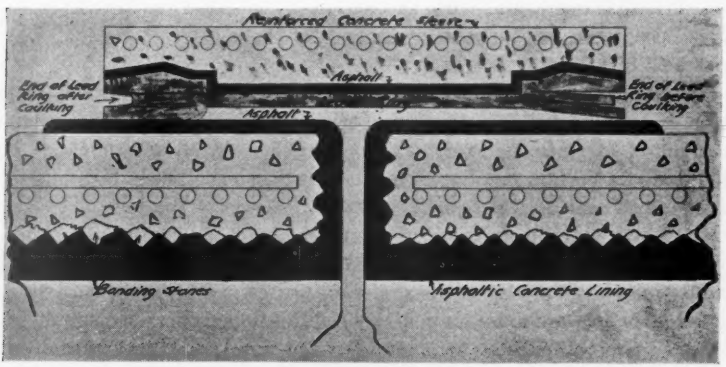


FIG. 10. — EXPANSION JOINT FOR ASPHALT-LINED CONCRETE PIPES.

Such a joint permits of ample movement to take up any variation in length of the pipe due to temperature changes and is water-tight, easily made and cheap. Other joints that have been tried out with success, but are more costly, employ lead as a caulking medium to secure a water-tight, flexible expansion joint. (Fig. 10.) In this case, the groove between the

ends of the abutting pipes is filled with asphalt as before, and a pre-cast, reinforced concrete sleeve, having a ring of lead on its inner periphery, is slipped over the asphalted joint. The lead ring is laminated at its ends in such a way as to present the form of three superimposed tongues. By caulking the center tongue, the two others are forced, one against the inside of the collar and the other against the outside of the pipe.

Modfications of this joint provide for the protection of the ends of the concrete pipe by a steel ring against which the lead is caulked. This joint has been tested up to 540 lb. per sq. in., and with an allowable longitudinal movement of 1 in. has preserved its water-tightness.

It is, of course, impossible to generalize on the subject of joints, since conditions vary considerably in any pipe line and often call for special treatment. One general principle, however, does obtain, namely, that the joint should be water-tight and as flexible as possible, consistent with first cost and general efficiency. It is for the engineer to satisfy himself that the joint to be used in a particular piece of work is suitable for that work and that the cost is not prohibitive.

COMPLETED PRESSURE JOINT.

FINISHED PRESSURE PIPE LINE.

DISCUSSION.

DANA M. WOOD.* I would like to ask Mr. Mitchell about the provision made for special connections; if it is possible to make those with this type of pipe.

MR. MITCHELL. So far, of course, it is not possible to spin a bend. Connections can be spun on and made integral with the pipe of the same consistency and material. The bends must be of cast iron or some similar material, or cast in place, if this is possible; that is to say, cast as a monolithic section lined with waterproof lining. The waterproof lining can be made up in sections and applied in the reverse method to that which I have described; a cylindrical asphalt sheet being made up and used as the inner form of the bend and the concrete poured around it. This, incidentally, was the original method of making the pipe. The centrifugal method is merely a commercial adaptation in order to cheapen the cost,

*Of Stone and Webster, Inc., Engineers, Boston, Mass.

and that is all; the stones are put into the concrete shell and the asphalt poured against them.

MR. WOOD. I suppose you can take up moderate angles in the pipe itself.

MR. MITCHELL. Yes. Joints have been opened as much as one inch and remained absolutely water-tight, so that we can easily take up lateral displacement. It is quite simple.

ARTHUR D. WESTON.* What is the maximum working pressure that you feel that this type of pipe can safely carry?

MR. MITCHELL. So far, we have not reached that limit. It is simply a function of the amount of steel reinforcement we can get into a particular concrete shell. The concrete shell is the tensile member and is not depended upon for water-tightness. In ordinary reinforced concrete construction, hair cracks develop in the concrete beams at the point of maximum bending and can be seen, though they do not interfere with the stability of the structure. Similarly, in a concrete shell under high pressure, cracks will develop. They can be seen, but the reinforcement maintains the integrity of the shell. By introducing a waterproof membrane, hair cracks may develop in the shell without interfering with the water-tightness of the pipe.

MR. WESTON. What are some of the maximum pressures of the pipe in use now?

MR. MITCHELL. Actually 100 lb. per sq. in. As I say, it is entirely new and there is only one line in actual operation. We have, however, taken test lines up to 300 lbs.:— that is, test lines 200 ft. long joined together at their ends. These lines have been under pressure for two years now.

MR. WESTON. Have you carried out any experiments to determine the friction losses in this pipe as compared to cast iron?

MR. MITCHELL. No. It has not been in use long enough to do that. It is hardly fair to use such an analogy, but the interior surface is similar to that of the asphalt-lined cast-iron pipe on exhibit here. It is exactly the same in principle,— the shell being of cast iron instead of concrete. The friction loss is very small indeed.

MR. WESTON. Has the value been determined in this line that you have already under operation?

MR. MITCHELL. No, sir, but it is certainly comparable with that of the best concrete pipe.

J. WALTER ACKERMANN.† Will Mr. Mitchell tell us a little more of the character of the water-tight element; what its physical characteristics are?

MR. MITCHELL. The actual proportions of the mix I shall not divulge. But it is an asphaltic concrete, which is a bitumen with silicate sand, a filler consisting of lime flour, or finely ground silicate — depending on the water

*Massachusetts State Department of Health, Boston, Mass.
†City Manager, Watertown, N. Y.

we have to deal with — and a coarse aggregate, seldom more than a quarter inch. It is a road material, practically speaking, an elastic road material, very hard and durable. The temperature and the actual proportions of filler to bitumen must be controlled absolutely.

JOHN F. SKINNER.* Could you give us an idea, approximately, of the relation of cost of this pipe per foot to, we shall say, cast-iron pipe of similar diameter, and also in sewer construction to the ordinary concrete sewers?

MR. MITCHELL. The addition of the asphaltic concrete is simply the addition of material that replaces concrete and is only slightly more expensive; the additional operation is not expensive. In large-diameter pipes, and pipes that are under pressures of over 100 ft., the actual cost of an asphalt-lined pipe is slightly less than that of a concrete pipe. When it comes to sewer work, however, we have a different condition to meet. The pressure is external, no longer internal, and the concrete shell itself must be sufficiently thick to take the compressive stresses, so that the asphalt lining in this case is additional to the thickness of the concrete shell as against the water pipe in which the asphalt lining replaces part of the concrete shell. In the case of a concrete sewer pipe, the addition of the asphalt lining will naturally make it more expensive.

MR. WESTON. What would you say would be the relative effect of acids in the sewage on this type of pipe as compared with concrete sewer pipe?

MR. MITCHELL. The asphalt is not affected by acids at all, therefore it forms an ideal protection in sewers where acids are met; as a matter of fact, it is proposed to carry out experiments in Los Angeles on the protection of the main sewer with asphalt of this nature. So far, the asphalt that has been used to protect concrete work has been merely an asphaltum or bitumen, a very plastic and unstable material, with the result that in the soffit of the arch of a concrete pipe stalactites of asphalt form. This sort of thing is of no earthly use. It may be very efficient as waterproofing, and may be very efficient as an acid-resisting medium, but it must be stable, and where stability is required, it must be of the nature of an asphaltic concrete, not an asphaltum.

MR. ACKERMANN. Water pipes of this material, you say, will not corrode.

MR. MITCHELL. There is nothing to corrode. The water does not get near the steel reinforcement, and therefore it does not corrode. Any collection of foreign matter in the pipe must be from the water itself. So far as the mains that have been laid with asphalt linings, either steel or cast iron, are concerned, the asphalt lining has not been affected for some fifty or sixty years. The best example I know of is that of the water main across the bay at San Francisco, which was laid in the late fifties and was recently examined. The lining was in perfect condition, with no deposit of any description.

*Sanitary Engineer, Department of Public Works, Rochester, N. Y.

GEORGE F. MERRILL.* Does the lining warm up when left inside the trench?

MR. MITCHELL. We are dealing with asphaltic concrete, and regulate the type of mix to be used for different jobs. Pipe has been lying out for years under different conditions of climate without any sign of creep in the asphalt lining. There is not enough bitumen in the asphaltic concrete to permit it to creep; in other words, it is stable.

MR. SKINNER. Do you find in the case of an asphaltic coating that it will stand in that way under various temperatures, especially in the sun? Won't it change somewhat like an asphalt pavement?

MR. MITCHELL. No. In the first place, asphaltic concrete can be made so hard that it can't be touched with a sand blast. Comparisons have been made between steel and asphaltic concrete under the action of a sand blast, and while the steel is scored the asphaltic concrete is polished.

MR. WOOD. Has any form of tapping been adopted?

MR. MITCHELL. Yes, a form of tapping has been developed. It is very expensive. This type of pipe is not ideal for distribution mains. To tap into an asphaltic concrete pipe, one must employ a sleeve of some description and then bore through the shell of the pipe, which makes it more expensive than tapping iron pipe. This, of course, necessarily depends on the size of the tap to be made; a small tap is more simple; a large tap is not so easy.

*Ware, Mass.

THE NEW McTAVISH PUMPING STATION AT MONTREAL, QUEBEC.

BY CHARLES J. DES BAILLETS.*

[*Read September 19, 1928.*]

The city of Montreal is supplied with water through its own system and through a privately owned system of the Montreal Water and Power Company.

During the years 1926, 1927 and 1928, steps were taken by the city to acquire the Montreal Water and Power Company. Today the city of Montreal operates the two systems, and the Montreal Water Board is working on the problem of interconnecting the two water works and operating the whole system under one management.

In order to understand this interconnecting problem, it is necessary to examine Figs. 1–3 which show the separate systems and their proposed combination into one unit.

At present the McTavish Station serves the high-pressure system of the city. Montreal has been subdivided into three zones on account of its topography. Each of these zones operates with an average pressure at the taps of approximately 60 lb. per. sq. in.

The present output of the McTavish Station is approximatively 12 m.g.d. and the reservoir for this zone, called the Peel Street Reservoir, has a capacity of 2 m.g. Owing to the growth of this district and the necessity of connecting more services, the city of Montreal had decided before the acquisition of the Montreal Water and Power Company to increase the capacity of the McTavish Station to approximatively 30 m.g.d.

Since the acquisition of the Montreal Water and Power Company and, in order to operate two systems with the present staff of the city water department, it was found that the McTavish Station, by its location, could be made to serve the zone previously served, as well as the zone connected to the Outremont Reservoir of the Montreal Water and Power Company.

It was then decided that a new station should be built in which three pumps of 12 m.g.d. capacity would serve the present high-pressure district, as well as some of the Westmount district of the Montreal Water and Power Company by using the Côte-des-Neiges Reservoir of the company's system, instead of the Peel Street Reservoir of the city system. This procedure will increase the pressure of the McTavish zone by 25 lb.

In addition, three 15-m.g.d. pumps of the new McTavish Station will pump the water for the Outremont Reservoir, the suction of all six pumps being taken from the McTavish Reservoir.

The 48-in. pipe leading from the St. Gabriel Station of the Montreal

*Chief Engineer, Montreal Water Board, Montreal, P. Q.

Water and Power Company and passing in front of McTavish Reservoir will be directed into this reservoir, so that the water required by the Outremont district will be pumped by the city's Low-level Pumping Station at Atwater Avenue through this 48-in. pipe which will be connected at D'Argenson Street to one of the 48-in. mains of the Low-level Pumping

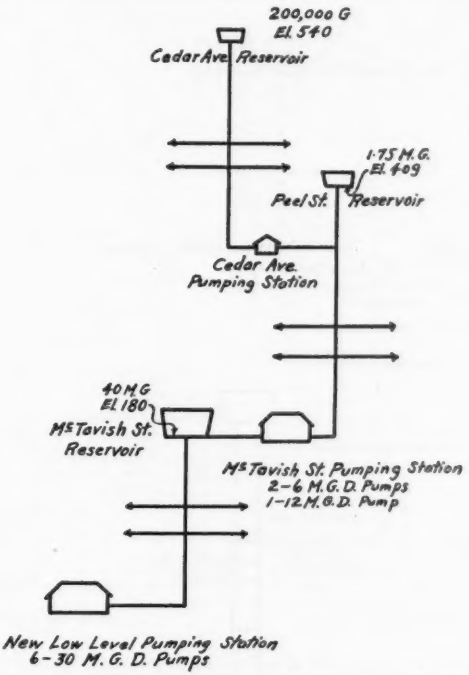


FIG. 1. — MONTREAL MUNICIPAL DISTRIBUTION SYSTEM BEFORE CONSOLIDATION.

Station. In this manner, the complete supply of the city of Montreal will be pumped in two existing stations, namely: the Low-level Pumping Station at Atwater Avenue which pumps the total supply, and the McTavish Pumping Station at McTavish Reservoir which repumps the water to higher zones: thus closing down the St. Gabriel Pumping Station and the Clark Pumping Station of the Montreal Water and Power Company.

These are the chief reasons that decided the Montreal Water Board to increase the present McTavish Station. At the same time, the walls of the reservoir will be raised on the south side, with the result that the reservoir's capacity will be increased by approximately 4 m.g.

THE NEW MCTAVISH STATION.

To conform to the character of the residential section in which this station is to be built, the architectural features of the building were selected to match existing beautiful structures, such as the Royal Victoria Hospital and McGill University. (Fig. 4.)

Foundations. The foundations all rest on rock.

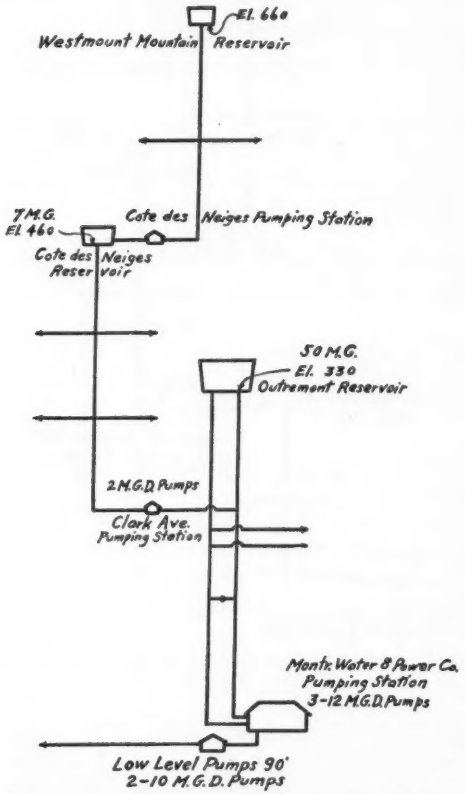


FIG. 2. — MONTREAL WATER AND POWER COMPANY DISTRIBUTION SYSTEM BEFORE CONSOLIDATION.

The station rests on an embankment, located immediately behind the retaining wall of the present reservoir. The location has been selected halfway on the Carleton Road so that the residents on McTavish Street will not be disturbed by station operation.

Water Connections. The water connections to the station are such that it can operate on each half of the reservoir, on the full reservoir and also independently of the reservoir.

Intakes. The suction for the six pumps is taken at the bottom of the reservoir, and the discharge of these pumps is connected in the street, three on the Outremont 48-in. main and three on the Côte-des-Neiges 36-in. main. The suction lines are controlled by hydraulically-operated butterfly valves, and the discharge of each line is controlled by a Johnson combination stop-and-check valve. These valves will automatically close the line in case of power interruption by means of a special relay that will close three

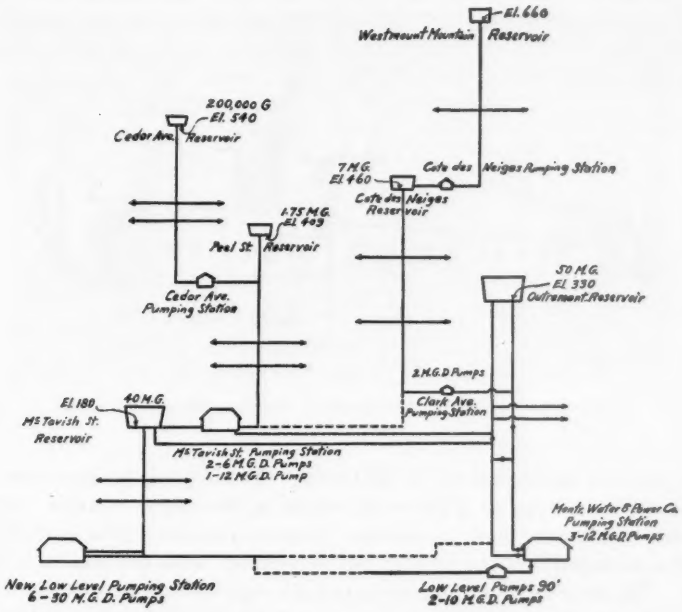


FIG. 3. — INTERCONNECTED SYSTEM OF DISTRIBUTION, MONTREAL, P. Q.

quarters of the stroke in about two or three seconds and the remainder of the stroke in a predetermined time, such as five to ten seconds, thus eliminating water hammer. The valves are controlled electrically from the main bench board in the control room of the station.

Pumping Units. The six pumping units will be of the two single-stage-pump-in-series type and will be driven by self-starting synchronous motors. These synchronous motors will have a capacity in K.V.A., such as to be able to carry the full load at 80 per cent. leading power factor. With this characteristic and with the six motors in operation, approximately 1 500 to 1 800 kilowatts will be made available for the power company for resale and the city will get the benefit of preferential rates.

The starting of these pumps will be automatic and the motors will be brought up to speed with the minimum current consumption.

The fields of the synchronous motors will be automatically opened in case of power interruption so that, if any one of the pumps is turning in reverse direction before the Johnson valve is closed, these motors will not act as generators and cause disturbance.

Power Supply. The power supply to the station will be effected by two 3-phase cables running from the Low-level Pumping Station at Atwater Avenue through an underground system of conduits and will deliver

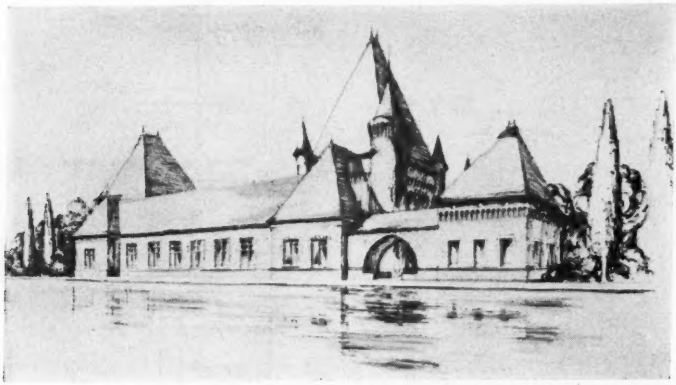


FIG. 4. — NEW MCTAVISH PUMPING STATION, MONTREAL, P. Q.

the power at approximately 11 000 volts. Two 3-phase transformers will reduce this voltage to 2 200 volts which is the motor voltage. All oil circuit-breakers for lines, transformer banks and motors will be in duplicate and so arranged that one breaker can be repaired, while the other is in service. The same applies to bus-bars on both high and low tension.

The two 3-phase cables being connected to the main Low-level Pumping Station, the power factor correction and voltage improvement due to the synchronous motors will be applied to the whole system of the city's pumping plants.

Control Board. The control board has been carefully designed, and on the same board the electrical and hydraulic apparatus are combined, so that the operator has before him the complete control equipment.

The oil circuit-breakers are operated by direct-current closing coils; so are the control motors for the Johnson valves. As a storage battery of ample capacity is provided with a motor generator set, all breakers and valves can be operated even when the main power is off.

Relay Protection. All motors and transformer banks are protected with differential relays and overload relays, in accordance with the latest electrical practice.

Temperature alarms are also provided for transformers.

High- and Low-tension Structures. All circuit-breakers and bus-bars,

both for the low and high tension are erected in concrete structures and separated so as to minimize the danger of flashing over from one apparatus to the other.

As this new station is the second one that the Montreal Water Board has designed, the first one being the present Low-level Pumping Station on Atwater Avenue, it may be interesting to know that, after operating the Low-level Pumping Station for five years, the board's expectations were fully realized for the electrical drive and control of the pumping units. The only improvements over the present station that we are introducing into the new one is the automatic starting of motors which, independently of the operator, will start all units under minimum starting-current conditions, resulting in minimum starting disturbances.

UNUSUAL METHODS OF WATER PURIFICATION.

BY MARTIN E. FLENTJE.*

[*Read September 19, 1928.*]

In taking over the supervision of the purification of water supplies of the companies connected with a central holding corporation, a number of rather unusual problems and methods of solution have been encountered.

Impounded supplies without filtration probably present a majority of such problems due to the absence of means for their prevention or elimination. The supplies of the New Rochelle Water Company, New Rochelle, N. Y., are typical impounded supplies, and considerable trouble has been encountered in their use. These supplies consist of four reservoirs, all with small watersheds. The highest of these reservoirs, No. 1, supplies the low-service distribution system of this company, by gravity. Another reservoir, No. 4, of practically the same elevation is used as storage and as supply for No. 1, the water from it being pumped to No. 1. The next lower reservoir, No. 3, feeds by gravity into a small reservoir, No. 2, in which the pump intake for the high-service distribution system is located. The pumping station is known as Union Corners Pump Station. Reservoir No. 2 is a small one, holding about 40 million gal. The water from No. 3 flows into it through a concrete flume, and then through 300 ft. of 36-in. tile. The general character of the water in these reservoirs is shown in the partial analysis listed in Table 1.

TABLE 1.—PARTIAL ANALYSIS OF WATER FROM NEW ROCHELLE RESERVOIR NO. 2.

	p.p.m.
Color	5–35
Turbidity	10
Total Hardness	58
Alkalinity	42
Chlorine	6.5
Nitrogen as:	
Nitrite	0.007
Nitrate	0.0
Carbon dioxide	3.0
pH	6.6–8.0+

This water at times becomes quite turbid and oftentimes quite highly colored. To remedy this situation an alum-treatment plant was installed in the flume line, immediately ahead of the 36-in. tile line. Water is al-

*Superintendent of Purification, Community Water Service Co., New York City.

lowed to flow from Reservoir No. 3 into Reservoir No. 2 at about the rate it is pumped into the distribution system (3 m.g.d.), allowing for approximately 10–13 days' retention. The alum container is made in the form sometimes found in solution-feed alum tanks, although considerably larger. Mixing is accomplished through the high velocities obtained in the tile line.

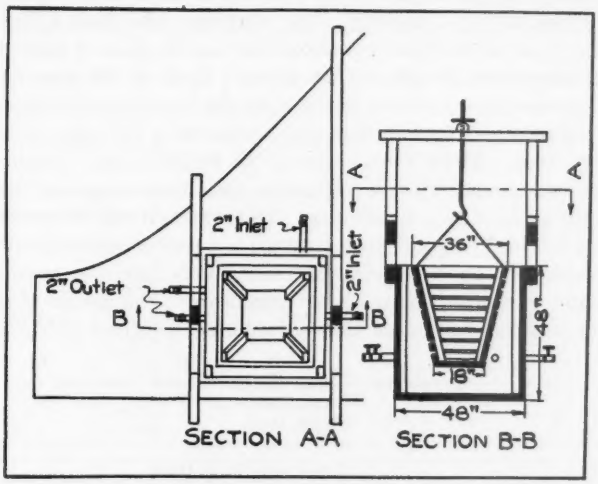


FIG. 1. — ALUM FEEDER USED AT NEW ROCHELLE, N. Y.

Partial aëration is also provided for, at the outlet of this line, by means of rocks and stones. A very good floc is obtained, and the following table

TABLE 2. — TURBIDITY AND COLOR REMOVAL WITH ALUM, NEW ROCHELLE, NEW YORK.

RESERVOIR NO. 2.

Alum dose: 80 lb. per m.g. Samples taken: 8/29/28

Sample No.	Distance from head of Reservoir, ft.	Turbidity, p.p.m.	Color.	
			p.p.m.	Per cent. reduction.
1*	0	11	35	..
2	150	11	25	28
3	750	..	17	51
4	1 200	..	17	51
5	1 800	6	15	57
6	2 000	..	14	60
7	2 500	6	11	68
8	Pump intake	5	10	71

*Reservoir No. 3.

illustrates the results that are being obtained in color and turbidity removal.

The treatment plant is shown in Fig. 1. It is easily adjusted, is flexible

and requires very little attention. The results obtained have been very satisfactory. Pre-chlorination is now being employed also at the same point. No results as to its effectiveness are as yet at hand.

Water fleas and Crustacea are often encountered in filtration plants, causing rapid clogging of filters. They are justly considered a nuisance, but when they appear in the water supplies of an unfiltered supply they become somewhat of a calamity. The consumer who finds a *Daphnia* or a *Cyclops*, or any of the other common forms, in his glass of water has just cause for complaint, though not for alarm. Early in the summer season of 1927, complaints were being received by the New Rochelle Water Company of the presence of water fleas and Crustacea in the water drawn from consumers' taps. These were found to be *Daphnia* and *Cyclops*. Fortunately it was found, upon investigation, that these organisms were confined to the head of No. 4 reservoir. This water, it will be remembered, is pumped to No. 1 reservoir to supply the low-service distribution system. Experiments, then and later, indicated that a very high dose of copper sulphate would be required to kill these organisms. The results of these experiments, together with some utilizing chlorine, are given in Table 3.

TABLE 3. — EFFECT OF COPPER SULPHATE AND CHLORINE ON WATER FLEAS.

$CuSO_4$ Used.

Dose, p.p.m.	EFFECT UPON FLEAS AFTER			
	24 hrs.	48 hrs.	72 hrs.	4–5 days.
0.25	None	None	None	Slight; few found dead
0.50	None	Few dead	Few dead	Few dead
1.00	Very slight	Few dead	Few dead	Majority dead
2.00	All dead	All dead	....	....

Chlorine Used.

Dose, p.p.m.	EFFECT UPON FLEAS AFTER				
	10 min.	25 min.	30 min.	1 hr.	12 hrs.
1.75	....	....	....	None	All dead
3.50	Activity noticeably diminished	Very few signs of life	All dead	....	....

It seemed inadvisable to employ the required dose of $CuSO_4$, especially since at one time, when one of the reservoirs was not being used, 10 lb. per million gal. were applied experimentally and no results were obtained. Chlorine was resorted to and has been used effectively since that time.

A Wallace & Tiernan MDA chlorinator with injector for solution feed, capacity 125 lb. per day, is used for this purpose. The chlorine is applied in the pump suction.

Taste complaints have been numerous at various times with this company, particularly during the winter months. The diatom *Asterionella*, as well as other microscopic organisms, is found the year around in these reservoirs, but such growths are easily controlled by the use of copper sulphate. Most of the trouble has been found to be due to the short time

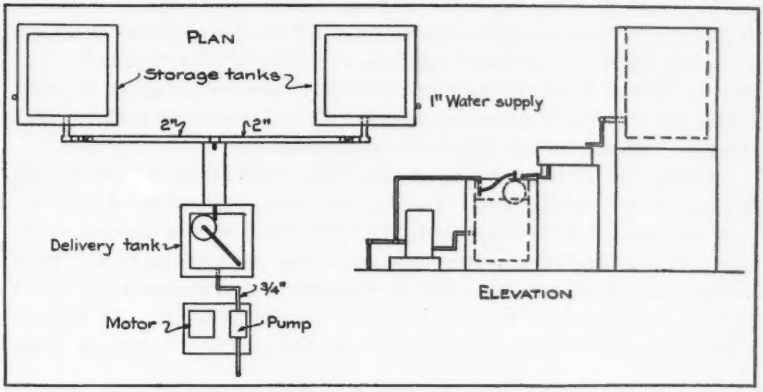


FIG. 2. — DECHLORINATION APPARATUS USED FOR APPLICATION OF SODA ASH AND SODIUM THIOSULPHATE.

elapsing between chlorination and use of the water. The tap water contained some residual chlorine, even though the chlorine dosage was being kept as low as possible, while still insuring disinfection. This condition became so bad that the high service had to be supplied entirely from the auxiliary supply, *i.e.*, Catskill water from New York City. On the low service, dechlorination seemed possible, because of the presence of a former hypochlorite of lime plant between chlorination and the first consumers. Sufficient reaction time also existed for the chlorine, ahead of this plant. The solution tanks were being used for the preparation and introduction of soda ash for the prevention of corrosion. Sodium thiosulphate was introduced with the soda ash, in sufficient quantities to react with the free chlorine remaining at this point, the exact dosage being controlled by residual-chlorine tests. Dechlorination has been used continuously for the last eight or nine months, and has practically solved the taste problem on this supply.

The method of applying the soda ash and sodium thiosulphate solution is worthy of mention. It makes use of storage tanks in duplicate, a constant-head orifice box, a delivery tank, and a plunger pump. The pump operates against the constant head in the transmission main and, by means

of a float-controlled valve in the delivery tank, pumps either into the main or through a by-pass back into the tank. The amount being added to the water is controlled by the amount flowing from the orifice box. This plant and system of pumping was successfully used for a number of years while calcium hypochlorite was being used for sterilization. It was designed by John G. DeVeau, Engineer for the New Rochelle Water Company. The general layout is shown in Fig. 2.

It has been rightly stated that the complexity of chemical treatment in water purification is increasing. However, the adoption of new chemicals is a very slow process, and those used can readily be named by anyone in the industry. One chemical product not at all common in water treatment is used at the Warren-Bristol water works to aid in color removal. This chemical is "whiting"; it has been effectively used for a number of years, solving the problem of providing sufficient alkalinity to react with the alum required, without the bad effects of soda ash or lime.

During the months of August, September and October, lime or soda ash can be successfully used. During the remaining months of the year, these two chemicals have a "peptizing" effect on the color present. The filter runs are shortened a great deal, requiring the washing of the filters in from one to two hours after their having been placed in operation. With whiting, these runs can be extended to seven or eight hours. An analysis of the whiting used is given in Table 4, together with the analysis of sludge

TABLE 4. — ANALYSIS OF "WHITING" AND SLUDGE.

	PERCENTAGE COMPOSITION.	
	Whiting.	Sludge.
Moisture	0.30	1.03
Insoluble	8.17	1.93
Fe and Al oxides	0.50	1.60
Calcium carbonate	90.76	81.02
Magnesium carbonate	0.0	15.41

obtained from a municipal lime-soda softening plant, owned by the same holding corporation. The similarity in composition is, of course, apparent, and the suggestion has been made that this sludge, after drying, might be substituted for the whiting. With this in mind some experimental work has been done, together with the other more common methods of color removal. However, at this time insufficient results have been obtained to make a report.

Table 5 gives a partial analysis of the Warren-Bristol water, the results being averages of results obtained during the summer months of 1928.

TABLE 5. — AVERAGE ANALYSIS OF WARREN-BRISTOL WATER. (Summer — 1928).

	RAW WATER.	SETTLED WATER.	TAP WATER.
Total hardness — p.p.m.	22.0	36.0	33.0
Alkalinity — p.p.m.	17.0	13.0	7.0
Carbon dioxide — p.p.m.	3.7	12.6	10.5
pH	7.1	6.6	6.2
Color — p.p.m.:			
Average	96	64	5
Maximum	130	75	8
Minimum	65	51	4
Percentage color removal	....	33	92

The increase in hardness, due to the use of whiting and alum, at this plant is shown in Table 6.

TABLE 6. — AVERAGE YEARLY HARDNESS (P.P.M.) OF WARREN-BRISTOL WATER.

Year.	RAW WATER.		FILTERED WATER.	
	Av.	Max.	Av.	Max.
1923	17.1	31.2	26.2	41.6
1924	21.2	27.3	26.7	35.1
1925	20.4	26.0	29.4	36.4
1926	23.5	28.6	34.7	44.3
1927	19.6	20.6	27.7	40.3
1900–1927	20.8	67.0	....	....
1913–1927	....	....	31.8	68.6

Due credit should be given to the different water companies for permission to present these data, particularly to the superintendents, Messrs. E. T. Cranch and J. M. Jones. Thanks also are due to J. G. DeVeau and H. G. Brown, Jr., Engineers, New Rochelle Water Company, and to P. S. Wilson, Superintendent of Operation, Community Water Service Company, New York City, who did the experimental work with chlorine in water-flea eradication.

THE OXY-ACETYLENE PROCESS IN MODERN INDUSTRY, WITH PARTICULAR REFERENCE TO THE PIPING FIELD.

BY R. W. BOGGS.*

[*Read September 20, 1928.*]

With the discovery of calcium carbide and the perfection of commercial methods for producing oxygen during the latter part of the nineteenth century, the way was opened for the development of the oxy-acetylene process. It is extremely doubtful whether those responsible for these discoveries realized the possibilities of this process. Within the last 25 years however, the scope of the process has expanded rapidly, until today it embraces practically every branch of industry. This paper will discuss some of the factors responsible for this development, with particular reference to the piping field.

One of the most important factors contributing to the successful use of the oxy-acetylene process has been the employment of a system outlining the procedure to be followed for any particular welding operation. This is called "procedure control"; or, to define it properly, "procedure control" is a system whereby each step of a production process is developed, supervised and controlled so as to secure the highest possible efficiency from each unit.

I will outline briefly a procedure control which is used for pipe welding, but which may be readily applied to other types of welding with very slight changes.

The subject may be divided into six groups, namely:

Check on welders.
Selection and inspection of material.
Design of the welded joint.
Preparation for welding.
Welding technique.
Inspection and test.

We shall consider them briefly in this order.

Check on Welders. All welders should pass a test in their welding ability before being accepted for any job. Their skill and experience in the type of work to be performed should also be considered. (Some companies operating large welding crews on pipe-line construction give their men a regular course of training before permitting them to start work.) The tests should be thorough and complete. There are several varieties of tests that may be used, depending upon facilities available. If it is possible to have a tensile test made of specimen welds, so much the better; but if this is

*Engineer, The Linde Air Products Co., New York, N. Y.

not possible, then a bending test may be performed. The test specimen is placed in a vise and bent over by hammering, the bend being made at the weld and against the V. Examination should be made to see that complete fusion has been obtained. In addition to these initial tests, each welder's work should be tested periodically, to be sure he is maintaining the proper standard.

Inspection and Selection of Material. All material should be inspected. In the selection of material the specifications should be thorough; they should specify the chemical analysis, physical strength and weldability of the base metal. The equipment and gases to be used should be the best available, for a welder can do his best work only when supplied with proper equipment and good materials. The choice of welding-rods is of considerable importance; it might be well to say a few words more with regard to this.

At the present time there are four grades of welding-rods commonly used for construction welding:

1. Low-carbon, soft-iron rods, better known as "Norway iron".
2. Mild-steel rods.
3. Nickel-steel rods.
4. High-test rods.

The first three can be purchased under the specifications of the American Welding Society, while the fourth is a rod that has been extensively used for a number of years by more than half of the American railroads for important welding operations.

Selection of satisfactory welding-rods is of importance to the designing engineer, because it assures weld metal of correct physical properties. During the welding operation, most of the carbon in the Norway and mild-steel rods and in that portion of the base metal that is incorporated in the weld is eliminated. Since carbon is the principal strengthening and hardening element in steel, it is evident that such weld metal, being very low in carbon, will be soft and ductile and have a relatively low tensile strength. Weld metal from nickel-steel rods contains sufficient nickel to have a characteristic hardness and strength, whereas the silicon and manganese in the high-test rods operate to form favorable metallurgical conditions during the welding operation to produce strong high-grade welds.

Design of Welded Joint. Under this heading should be included details with regard to the weld metal, such as penetration required, fusion, and the physical characteristics and dimensions of the weld. In the case of large-diameter pipes, which may be fabricated on the job from steel plates, specifications should be included with regard to the fabrication procedure. When stock pipe is used and is not furnished with the ends beveled for welding, it is necessary for this to be done on the job; then the type and manner in which the work is to be done — whether by machine or by use of a cutting blowpipe — should be specified.

Preparation for Welding. In preparing instructions for preparatory work it is important that thought be given to local factors encountered at the point of fabrication. For overland work, this includes a knowledge of the country to be crossed, while for inside work, such things as the interference of structural members must be considered. The instructions should cover the cleaning, alignment, spacing and tack-welding operations. The last two factors mentioned will vary with the size pipe being used.

Welding Technique. Under this subject should be outlined the factors governing the actual welding operation. The proper size of welding head to be used for the different thicknesses of pipe to be welded and the gas pressures to be used, as well as the proper size welding-rod, should be mentioned. In addition to this, the type of weld should be specified, whether flat or ripple, as well as its width.

Inspection and Test. Under inspection must be considered the qualifications of the inspector, his authority and his duties. It has been found that an experienced welding foreman or inspector can tell at a glance whether the welder is doing his work properly, welding through to the bottom of the V and working out the slag or any other inclusions. A common criticism of the welded joint is that it is incapable of inspection, that the welder is able to gloss over the work and make a good surface appearance; but that within, the weld itself may be wholly unsound. This is true only when a careless organization encourages slipshod work and when inspection is made by one wholly unfamiliar with the indications of good work. Important work in welding should no more be assigned to men or organizations whose integrity is uncertain than should the construction of a large bridge or other important structure.

Under testing should be specified the type of test to be used, methods of application, and approval standards. In pipe-line work this will include the length of the section to be tested at one time, the medium to be used, *i.e.*, whether the test is to be made with water, gas, oil or air, the pressure to be applied and specifications for making repairs to leaky joints, if any should occur.

As an illustration of what "procedure control" can do, when it is properly applied, I might cite an instance where it was used on the Pacific coast. It was desired to construct a seven-mile water line of 24- and 30-in. steel pipe. Because of prohibitive freight rates on this type of pipe, when shipped from the East, it was decided to have flat boiler plate shipped *via* the Panama Canal and to roll it into pipe upon arrival, welding both the longitudinal and circumferential seams on the job; in other words, the entire line was fabricated by oxwelding.

Not being familiar with the correct way to handle such an undertaking, the constructing company asked aid from their oxygen supplier, The Linde Air Products Company. A procedure control was prepared for the job by Linde engineers. A service operator supervised the work and trained the welders for two weeks. The line was laid, as outlined in the procedure

control, and met with complete success. Lost motion was eliminated, and a perfect job was obtained well within the contract time. There are other similar instances.

For a number of years the oxy-acetylene process has been thoroughly understood by engineers interested in the construction of overland pipe-lines for oil and gas distribution and in the fabrication of power-plant and industrial piping. These men have found that with oxwelding they can obtain a joint that is strong, permanently tight and economical. They have learned, also, that it is not difficult to instruct mechanically-minded workmen in the technique of oxwelding, and that, when properly instructed and supervised, these men can produce joints in steel and cast-iron pipe that will compare favorably in strength with the rated strength of the pipe wall itself.

It is interesting to note the statement of prominent engineers with regard to oxwelding. A. W. Moulder, Manager of the Heating and Industrial Piping Division of the Grinnell Company, Inc., in a paper read before a joint meeting of the American Society of Mechanical Engineers and the American Welding Society, in New York City, stated that his company had been installing welded piping for more than 18 years for all sorts of service, ranging from water piping to high-pressure steam piping; during that time they had never received a report of a failure of a welded joint made under their direction.

In an article that appeared recently in the *Oil and Gas Journal*, William J. Heltzell, Engineer with the Sinclair Pipe Line Company, made the following statement: "Practically all of the trunk oil-lines laid this year are acetylene-welded lines. This year has marked the passing of the screwed line for trunk-line construction. The passing of the screwed-joint line and the almost universal use of the welded joint marked another milepost in the progress of pipe-line practice. . . . The extensive use of oxy-acetylene welding has marked the passing of large heavy cast fittings. A collection of large idle cast-iron fittings about pipe-line warehouses is a familiar sight; this equipment has become obsolete through the use of welding which has not only facilitated pipe-line work, but has also made possible a considerable reduction in the inventory of materials and effected a considerable saving where cast-iron fittings were used before."

N. E. Wagner, Superintendent of Welding of the Prairie Pipe Line Company, has described the laying of hundreds of miles of oxwelded lines and reports that his company has entirely done away with the usual line-walkers, men who travel up and down oil and natural-gas lines looking for leaks, because in a welded joint, properly made, there are no leaks, either when the line is first laid or after it has been in service.

E. E. Lundgren, Chief Engineer of the Western United Gas and Electric Company, has stated that his experience has similarly been very favorable to oxwelded lines; and furthermore, he makes the statement that, based on his experience with several thousand miles of welded pipe ranging from

12 to 4 in., he has found that not only are welded joints better and quicker to install, but they are also less expensive than screw-coupled joints.

From these statements it may be gathered that with experienced workmen one may be assured of good results, but the engineer or designer must be convinced that such results are also obtainable at the hands of the average workman. Data on the uniformity of work performed by the average production welder are available.

A recent test was made of the work of 76 welders employed by American railroads. These men made up tensile test pieces, using both Norway-iron and high-test welding rods on $\frac{3}{8}$-in. boiler plate. All of these pieces were of the single V type. A large number of test pieces were made with each rod. When plotted the curves representing the strengths of the high-test rods and the Norway-iron rods were strikingly parallel: for the greater part of their length they differed by about 8 500 lb. This gives a strong indication of the uniformity and reliability of the welding done by 76 welders of average ability in one commercial organization.

Furthermore, 73 per cent. of the test pieces on high-test rods showed a strength of over 50 000 lb. per sq. in., and 60 per cent. of the Norway-iron rods exceeded 42 000 lb. per sq. in. This is certainly an indication of the uniform strength of welds made by average workmen.

The National Tube Company recently conducted a number of tests on different types of welded pipe-joints, during which several very interesting facts were brought out. The tests showed that the standard of workmanship, *i.e.*, the dependability and uniformity of the welds made by a skilled operator, does not vary to such an extent that designers should set up additional factors of safety to allow for variation in any one man's workmanship.

Discussion.

H. O. Lacount.* Possibly because of my bringing up in fire-protection engineering I was looking for some reference in Mr. Boggs' paper to the need of precautions, safeguarding against starting fire, where the welding or cutting process is carried on inside of plants.

This factor has rather impressed itself upon us in the Factory Mutual Inspection Department, for our records have shown almost an epidemic during this past year or so of fires starting from these processes. Therefore, while we are considering this subject, I think it would be in order to include a word regarding the possible hazard from sparks, *i.e.*, bits of molten metal, etc., flying around where they can get into combustibles and start fires.

I recall one rather interesting case where precautions were taken, and yet a piece of hot metal found its way through a crack in the floor, and quickly ignited some highly combustible material on the floor below, causing a loss of several thousand dollars. That was occasioned by the oxy-

*Factory Mutual Fire Insurance Companies, Boston, Mass.

acetylene process; so that some rather unusual precautions are sometimes necessary to protect certain occupancies when welding or cutting comes into industrial plants.

MR. BOGGS. With regard to this phase of the subject, I have witnessed a great number of industrial operations of this type, and I have yet to see a fire. I think it comes down more or less to a personal element of the men doing the work. In other words, if the proper precautions are taken, using asbestos board, or, in places where it is impossible to employ asbestos board, using a plastic mix of asbestos, I do not think there will be any danger.

MR. LACOUNT. I think you can take such precautions as will make the process reasonably safe, but there are conditions such as in a cotton warehouse, where you want to look out, because there you will find plenty of good cotton or other combustibles that will burn. I think the number of oxy-acetylene fires reported to our office during 1927 and the first few months of this year is 50 or 60. As I say, there was almost an epidemic of them, scattered, of course, through different parts of the country. So this phase of the subject is quite on our minds.

AVERAGE RAINFALL TABLES FOR NORTHERN NEW ENGLAND.

BY GRAGG RICHARDS.*

The numerical data on which were based the maps and discussion presented in the December, 1928, JOURNAL of this Association are presented in the following tables:

MEAN SEASONAL RAINFALL.
Adjusted to 1881–1925.

Maine.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Ashland	7.5	10.1	9.6	7.6	34.8
Azischos Dam	8.5	12.1	9.5	6.7	36.8
Bar Harbor	12.6	10.2	12.6	13.6	49.0
Belfast	10.4	10.2	10.9	13.6	45.1
Calais	11.7	10.5	11.9	13.6	47.7
Camden	11.0	9.3	12.9	9.2	42.4
Cornish	11.65	12.19	11.46	11.56	46.86
Danforth	8.9	9.8	10.7	10.6	40.0
Eastport	9.70	8.82	9.39	11.03	38.94
Fairfield	8.2	9.3	8.2	8.7	34.4
Farmington	11.1	11.1	10.7	10.6	43.5
Flagstaff	8.3	11.1	9.0	8.3	36.7
Gardiner	10.74	9.83	10.52	11.27	42.36
Greenville	10.6	13.0	11.8	10.1	45.5
Houlton	6.2	7.7	8.1	7.1	29.1
Jackman	9.4	12.1	8.6	8.2	38.3
Kineo	7.9	11.4	7.4	7.3	34.0
Lewiston	11.15	10.19	10.44	11.69	43.47
Livermore	10.7	11.3	11.2	9.8	43.0
Madison	11.6	12.2	11.4	10.9	46.1
Mayfield	10.8	13.6	11.9	10.4	46.7
Middle Dam	7.9	12.0	8.9	6.3	35.1
Millinocket	9.9	11.6	11.8	10.7	44.0
Milo	9.6	11.2	11.7	6.9	39.4
N. Bridgton	11.2	11.8	10.7	11.2	44.9
Old Town	10.3	11.0	11.1	9.9	42.3
Oquossoc	9.2	11.3	9.0	9.4	38.9
Orono	9.87	10.05	10.45	10.87	41.24
Patten	8.5	11.3	11.7	8.8	40.3
Portland	10.97	9.70	9.71	11.95	42.33
Presque Isle	8.1	8.9	8.8	10.4	36.2
Rumford Falls	10.0	11.3	10.3	9.5	41.1
Songo	10.7	10.8	10.1	10.9	42.5
The Forks	9.3	13.2	10.0	8.1	40.6
Upper Dam	7.64	9.95	8.26	6.93	32.78
Van Buren	8.0	11.8	9.2	7.9	36.9
Winslow	9.4	10.3	9.9	8.9	38.5
Woodland	11.2	8.7	13.1	10.6	43.6
Wytopitlock	9.2	11.0	11.6	8.5	40.3

*Mining Geologist, Detroit, Mich.

New Hampshire.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Alstead	9.1	11.7	10.5	8.7	40.0
Belmont	8.9	10.3	9.6	11.2	40.0
Berlin	8.4	11.2	9.2	8.2	37.0
Berlin Mills	8.7	10.6	9.2	9.1	37.6
Bethlehem	8.5	12.2	10.2	7.5	38.4
Bristol	10.3	10.8	10.0	10.4	41.5
Brookline	10.9	10.8	10.5	10.2	42.4
Concord	8.96	10.20	9.17	9.03	37.36
Durham	9.7	9.9	10.3	10.5	40.4
Errol	8.27	11.49	9.45	8.28	37.49
Fitzwilliam	10.7	13.1	11.3	10.3	45.4
Franklin	10.0	11.6	10.5	10.0	42.1
Glencliff	10.2	12.1	11.1	9.5	42.9
Gorham	8.5	9.7	9.0	7.4	34.6
Grafton	9.0	10.7	9.3	9.3	38.3
Hanover	8.42	10.23	8.83	7.43	34.91
Keene	8.9	10.9	9.5	8.9	38.2
Lakeport	10.34	10.58	10.05	11.17	42.14
Littleton	8.3	11.4	10.0	9.1	38.8
Manchester	9.92	9.83	9.50	9.96	39.21
Mt. Washington	18.03	28.04	22.49	13.65	82.21
Nashua	9.83	9.84	9.26	10.40	39.33
Newton	10.0	9.8	10.2	10.0	40.0
North Conway	9.9	9.9	9.5	11.9	41.2
Peterboro	9.3	11.0	10.0	10.1	40.4
Pittsburg (a)	8.6	11.9	11.6	8.7	40.8
Pittsburg (b)	9.7	13.3	12.2	9.8	45.0
Plymouth	9.41	11.09	10.19	9.60	40.29
Profile	....	....	....	....	50.9
Sanbornton	8.8	11.2	9.9	7.8	37.7
Stratford	7.6	12.2	9.7	7.1	36.6
Weirs	9.7	10.8	9.4	10.6	40.5
West Milan	8.1	11.6	9.7	10.6	40.0
West Stewartstown	5.8	10.9	8.6	5.9	31.2
Wolfeboro	10.2	10.3	9.7	11.7	41.9
Woodstock	10.6	14.6	12.2	10.6	48.0
Woodville	7.7	10.4	8.6	8.2	34.9

Vermont.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Bellows Falls	8.5	9.6	8.9	8.0	35.0
Bennington	8.8	12.5	10.1	9.4	40.8
Bloomfield	8.0	12.5	9.9	6.5	36.9
Brattleboro	9.7	10.1	10.2	10.9	40.9
Burlington	7.22	10.45	8.96	5.15	31.78
Cavendish	9.1	10.8	9.7	8.8	38.4
Chelsea	8.51	10.21	8.97	7.88	35.57
Cornwall	6.7	10.0	8.4	6.1	31.2
Enosburg Falls	8.7	12.6	10.5	7.6	39.4
Fitzdale	6.4	11.1	7.7	5.1	30.3
Garfield	8.6	12.5	10.0	9.0	40.1
Guildhall	6.7	12.4	8.2	5.1	32.4
Halifax	9.6	10.3	10.0	11.0	40.9
Hyde Park	8.1	12.8	10.8	7.2	38.9
Jacksonville	10.7	10.6	11.3	11.8	44.4
Londonderry	9.0	10.0	8.7	8.4	36.1
Manchester	9.7	10.9	11.3	9.2	41.1
Morrisville	....	....	....	....	....
Northfield	7.69	10.10	8.35	6.80	32.94
Norwich	8.7	10.5	9.3	8.7	37.2
Readsboro	11.7	14.0	11.5	10.8	48.0
Ryegate	7.9	11.3	7.9	6.5	33.6
St. Johnsbury	7.96	11.11	9.11	6.69	34.87
Somerset	11.8	13.7	13.4	13.6	52.5
Strafford	9.0	11.4	9.5	9.0	38.9
Vernon	9.8	10.7	10.6	9.1	40.2
Victory	7.9	14.1	10.2	5.8	38.0
Wells	8.9	11.2	9.7	8.7	38.5
West Hartland	9.8	11.1	10.0	8.7	39.6
West Rutland	8.1	9.5	8.7	7.1	33.4
White River Jct.	8.1	9.0	8.8	7.4	33.3
Wilmington	10.6	13.2	11.3	12.3	47.4
Woodstock	9.41	10.58	9.50	8.63	38.12

MEAN MONTHLY RAINFALL.
Adjusted to 1881–1925.

Maine.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Ashland	1.9	3.2	2.5	2.1	2.9	3.6	3.1	3.4	2.6	4.5	2.5	2.5	34.8
Azischos Dam	2.6	1.9	2.8	2.4	3.3	3.9	3.9	4.3	3.8	2.8	2.9	2.2	36.8
Bar Harbor	4.8	4.2	5.2	3.6	3.8	3.2	3.6	3.4	3.8	4.2	4.6	4.6	49.0
Belfast	4.7	4.3	4.5	2.8	3.1	3.4	3.6	3.2	3.5	3.5	3.9	4.6	45.1
Calais	4.7	4.3	4.7	3.5	3.5	3.2	3.6	3.7	3.3	4.4	4.2	4.6	47.7
Camden	3.0	2.4	2.8	3.4	3.8	3.0	3.2	3.1	4.2	4.6	4.1	3.8	42.4
Cornish	3.77	3.98	4.25	3.60	3.80	3.88	4.17	4.14	3.84	3.66	3.96	3.81	46.86
Danforth	3.8	3.7	3.3	2.9	2.7	3.3	3.5	3.0	3.1	3.4	4.2	3.1	40.0
Eastport	3.91	3.38	3.83	2.81	3.06	2.91	2.97	2.94	2.70	3.43	3.26	3.74	38.94
Fairfield	2.9	2.8	3.0	2.4	2.8	2.7	3.4	3.2	2.9	2.7	2.6	3.0	34.4
Farmington	3.5	3.4	4.0	3.3	3.8	3.8	3.6	3.7	3.8	3.5	3.4	3.7	43.5
Flagstaff	2.9	2.6	3.0	2.5	2.8	4.0	3.6	3.5	3.1	2.9	3.0	2.8	36.7
Gardiner	3.92	3.64	4.10	3.27	3.37	3.23	3.50	3.10	3.52	3.59	3.41	3.71	42.36
Greenville	3.2	3.2	3.80	3.0	3.8	4.1	4.7	4.2	4.2	3.5	4.1	3.7	45.5
Houlton	2.4	2.4	2.5	1.8	1.9	2.7	2.4	2.6	2.6	3.2	2.3	2.3	29.1
Jackman	2.6	2.9	3.0	2.3	4.1	4.7	4.4	3.0	2.4	2.8	3.4	2.7	38.3
Kineo	2.0	1.9	2.4	3.1	2.4	3.7	4.6	3.1	2.1	2.1	3.2	3.4	34.0
Lewiston	3.95	3.82	4.17	3.39	3.59	3.44	3.72	3.03	3.54	3.39	3.51	3.92	43.47
Livermore	3.4	3.2	4.0	3.3	3.4	3.5	3.3	4.5	3.8	3.7	3.7	3.2	43.0
Madison	3.8	3.5	3.9	3.6	4.1	4.2	3.8	4.2	4.0	3.7	3.7	3.6	46.1
Mayfield	3.5	3.3	3.7	3.3	3.8	4.3	5.0	4.3	3.8	3.9	4.2	3.6	46.7
Middle Dam	2.4	1.8	2.5	2.1	3.3	3.9	4.0	4.1	3.6	2.6	2.7	2.1	35.1
Millinocket	3.6	3.4	3.7	3.0	3.2	3.8	3.7	4.1	3.7	3.6	4.5	3.7	44.0
Milo	2.6	2.5	3.0	2.0	4.6	3.9	3.4	3.9	3.3	3.8	4.6	1.8	39.4
N. Bridgton	3.7	3.8	4.0	3.4	3.8	3.7	4.3	3.8	3.8	3.3	3.6	3.7	44.9
Old Town	3.0	3.2	3.6	3.1	3.6	3.4	3.5	4.1	3.6	3.5	4.0	3.7	42.3
Oquossoc	3.2	3.2	3.5	2.3	3.4	3.5	4.3	3.5	3.9	2.4	2.7	3.0	38.9
Orono	3.92	3.47	3.67	2.90	3.30	3.39	3.43	3.23	3.54	3.34	3.57	3.48	41.24
Patten	3.0	3.0	2.8	2.3	3.4	4.1	3.8	3.4	4.1	3.9	3.7	2.8	40.3
Portland	3.98	4.00	4.01	3.41	3.55	3.26	3.30	3.14	3.21	3.11	3.39	3.97	42.33
Presque Isle	3.0	3.9	2.7	2.4	3.0	3.2	2.7	3.0	2.9	3.3	2.6	3.5	36.2
Rumford Falls	3.1	3.3	3.3	3.0	3.7	3.7	3.8	3.8	3.7	3.2	3.4	3.1	41.1
Songo	3.8	3.6	3.6	3.4	3.7	3.3	3.8	3.7	3.0	3.9	3.2	3.5	42.5
The Forks	2.6	2.9	2.7	2.8	3.8	4.3	5.5	3.4	3.4	3.0	3.6	2.6	40.6
Upper Dam	2.48	2.07	2.58	2.19	2.87	3.32	3.33	3.30	3.14	2.45	2.67	2.38	32.78
Van Buren	2.6	2.6	2.8	1.9	3.3	4.1	3.7	4.0	3.0	3.8	2.4	2.7	36.9
Winslow	3.1	2.8	3.4	2.8	3.2	3.1	3.8	3.4	3.5	3.4	3.0	3.0	38.5
Woodland	3.7	2.7	3.7	4.0	3.5	3.6	2.1	3.0	4.1	4.7	4.3	4.2	43.6
Wytopitlock	3.1	2.6	3.2	2.6	3.4	4.2	2.8	4.0	4.1	3.7	3.8	2.8	40.3

New Hampshire.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Alstead	2.9	2.8	3.1	2.8	3.2	3.6	4.1	4.0	3.8	3.0	3.7	3.0	40.0
Belmont	3.8	3.6	3.8	2.2	2.9	3.1	3.5	3.7	3.3	2.9	3.4	3.8	40.0
Berlin	2.8	2.6	3.2	2.6	2.6	3.9	3.7	3.6	3.4	2.8	3.0	2.8	37.0
Berlin Mills	3.1	3.0	3.3	2.6	2.8	3.6	3.3	3.7	3.3	2.8	3.1	3.0	37.6
Bethlehem	2.5	2.4	2.9	2.5	3.1	4.0	4.2	4.0	3.8	3.1	3.3	2.6	38.4
Bristol	3.6	3.1	3.5	3.7	3.1	3.7	3.6	3.5	2.9	3.3	3.8	3.7	41.5
Brookline	3.4	3.4	3.9	3.5	3.5	3.4	3.6	3.8	3.7	3.4	3.4	3.4	42.4
Concord	3.03	2.89	3.14	2.74	3.08	3.19	3.49	3.52	3.46	2.79	2.92	3.11	37.36
Durham	3.7	3.3	3.1	3.1	3.5	3.5	3.2	3.2	3.8	3.4	3.1	3.5	40.4
Errol	2.78	2.65	2.88	2.58	2.81	3.80	3.72	3.97	3.42	3.01	3.02	2.85	37.49
Fitzwilliam	3.3	3.7	3.5	3.8	3.4	4.2	4.2	4.7	3.8	3.5	4.0	3.3	45.4
Franklin	3.4	3.4	3.6	3.1	3.3	4.0	3.8	3.8	3.9	3.3	3.3	3.2	42.1
Glencliff	3.1	3.1	3.3	3.3	3.6	3.7	4.1	4.3	4.0	3.6	3.5	3.3	42.9
Gorham	2.3	2.4	3.0	2.7	2.8	3.4	3.0	3.3	3.1	2.6	3.3	2.7	34.6
Grafton	3.2	3.2	3.1	2.5	3.4	3.0	4.1	3.6	3.3	3.0	3.0	2.9	38.3
Hanover	2.50	2.45	2.79	2.44	3.19	3.39	3.50	3.34	3.38	2.66	2.79	2.48	34.91
Keene	3.0	2.8	3.1	2.7	3.1	3.0	3.8	4.1	3.7	2.9	2.9	3.1	38.2
Lakeport	3.69	3.78	4.03	3.14	3.17	3.37	3.76	3.45	3.59	2.98	3.48	3.70	42.14
Littleton	2.9	3.2	2.9	2.2	3.2	3.9	3.7	3.8	3.2	3.1	3.7	3.0	38.8
Manchester	3.36	3.23	3.65	3.01	3.26	2.99	3.52	3.32	3.38	2.91	3.21	3.37	39.21
Mt. Washington	4.27	4.16	5.92	5.94	6.17	9.08	10.34	8.62	8.42	7.45	6.62	5.22	82.21
Nashua	3.49	3.53	3.72	3.09	3.02	2.97	3.42	3.45	3.19	2.93	3.14	3.38	39.33
Newton	3.6	3.3	3.3	3.3	3.4	3.3	3.3	3.2	3.4	3.4	3.4	3.1	40.0
North Conway	3.8	3.7	3.5	3.1	3.3	3.2	3.7	3.0	3.0	3.2	3.3	4.4	41.2
Peterboro	3.4	3.3	3.4	3.0	2.9	3.7	3.4	3.9	3.8	3.0	3.2	3.4	40.4
Pittsburg (a)	3.0	2.5	3.1	2.5	3.0	4.6	3.4	3.9	4.8	3.6	3.2	3.2	40.8
Pittsburg (b)	3.1	3.1	3.4	2.6	3.7	5.5	3.9	3.9	5.2	3.8	3.2	3.6	45.0
Plymouth	3.23	3.07	3.38	2.81	3.22	3.64	3.77	3.68	3.72	3.19	3.28	3.30	40.29
Profile	...	...	...	...	...	...	...	...	...	...	...	...	50.9
Sanbornton	2.7	2.4	3.0	2.5	3.3	3.4	4.3	3.5	3.9	2.9	3.1	2.7	37.7
Stratford	2.4	2.0	2.5	2.1	3.0	3.9	4.4	3.9	3.7	3.1	2.9	2.7	36.6
Weirs	3.5	3.5	3.5	3.0	3.2	3.8	3.7	3.3	3.6	2.7	3.1	3.6	40.5
West Milan	3.8	3.4	2.9	2.4	2.8	4.0	3.9	3.7	3.5	2.9	3.3	3.4	40.0
W. Stewartstown	2.2	2.0	2.1	1.7	2.0	3.7	3.6	3.6	3.6	2.9	2.1	1.7	31.2
Wolfeboro	4.2	3.8	3.7	3.3	3.2	3.4	3.9	3.0	3.5	2.9	3.3	3.7	41.9
Woodstock	3.4	3.5	3.9	2.8	3.9	4.0	5.0	5.6	4.7	4.0	3.5	3.7	48.0
Woodville	2.6	2.8	3.0	1.9	2.8	3.8	3.7	2.9	3.2	2.9	2.5	2.8	34.9

Vermont.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Bellows Falls	2.6	2.7	2.9	2.2	3.4	2.9	3.4	3.3	2.9	2.5	3.5	2.7	35.0
Bennington	2.6	4.0	2.9	2.2	3.7	4.3	4.5	3.7	4.0	3.1	3.0	2.8	40.8
Bloomfield	2.2	2.0	2.5	2.5	3.0	3.8	4.6	4.1	4.0	3.1	2.8	2.3	36.9
Brattleboro	3.8	3.5	3.6	3.0	3.1	2.9	3.1	4.1	3.3	3.5	3.4	3.6	40.9
Burlington	1.67	1.63	2.11	2.18	2.93	3.60	3.46	3.39	3.64	2.84	2.48	1.85	31.78
Cavendish	3.1	2.7	2.9	2.7	3.5	3.2	4.1	3.5	3.5	3.0	3.2	3.0	38.4
Chelsea	2.70	2.63	2.98	2.55	2.98	3.32	3.33	3.56	3.40	2.67	2.90	2.55	35.57
Cornwall	2.0	2.0	2.0	2.0	2.7	3.4	3.4	3.2	3.2	2.7	2.5	2.1	31.2
Enosburg Falls	2.5	2.4	2.7	2.6	3.4	4.4	4.4	3.8	4.0	3.6	2.9	2.7	39.4
Fitzdale	1.6	1.4	1.9	1.9	2.6	3.8	4.0	3.3	2.8	2.6	2.3	2.1	30.3
Garfield	3.4	2.5	2.6	2.5	3.5	3.6	3.9	5.0	3.7	3.5	2.8	3.1	40.1
Guildhall	1.8	1.7	2.0	1.9	2.8	3.5	4.5	4.4	3.4	2.7	2.1	1.6	32.4
Halifax	3.9	3.5	3.2	2.8	3.6	3.1	3.5	3.7	3.5	3.0	3.5	3.6	40.9
Hyde Park	2.4	2.2	2.4	2.7	3.0	4.1	5.0	3.7	4.7	3.0	3.1	2.6	38.9
Jacksonville	4.0	4.3	3.7	3.5	3.5	3.2	3.8	3.6	4.2	3.6	3.5	3.5	44.4
Londonderry	2.8	2.8	2.8	3.1	3.1	3.2	3.6	3.2	2.7	3.1	2.9	2.8	36.1
Manchester	3.1	3.1	2.9	2.6	4.2	3.1	3.6	4.2	4.8	3.4	3.1	3.0	41.1
Morrisville	...	...	...	...	...	...	...	...	...	...	...	...	...
Northfield	2.26	2.21	2.62	2.32	2.75	3.22	3.46	3.42	3.06	2.69	2.60	2.33	32.94
Norwich	3.1	2.7	2.9	2.5	3.3	3.4	3.6	3.5	3.5	2.8	3.0	2.9	37.2
Readsboro	3.6	3.2	3.3	3.7	4.7	4.9	4.3	4.8	3.6	4.1	3.8	4.0	48.0
Ryegate	2.0	2.2	2.8	2.4	2.7	3.1	4.4	3.8	3.0	2.5	2.4	2.3	33.6
St. Johnsbury	2.15	2.16	2.63	2.51	2.82	3.39	3.86	3.86	3.72	2.77	2.62	2.38	34.87
Somerset	4.8	4.4	3.8	3.6	4.4	4.3	4.7	4.7	3.9	5.0	4.5	4.4	52.5
Strafford	3.0	2.9	3.3	2.3	3.4	3.7	3.8	3.9	3.3	3.0	3.2	3.1	38.9
Vernon	3.3	2.6	3.5	3.1	3.2	3.1	3.6	4.0	4.1	3.4	3.1	3.2	40.2
Victory	1.7	2.2	2.2	2.4	3.3	4.7	5.1	4.3	4.5	3.2	2.5	1.9	38.0
Wells	2.8	3.2	3.3	2.4	3.2	3.2	4.0	4.0	4.0	2.9	2.8	2.7	38.5
West Hartland	2.6	2.8	3.1	3.0	3.7	3.5	4.0	3.6	3.6	3.1	3.3	3.3	39.6
West Rutland	2.5	2.2	2.5	2.3	3.3	3.2	3.1	3.2	3.2	2.7	2.8	2.4	33.4
White River Jct.	2.6	2.3	2.9	2.2	3.0	3.0	3.1	2.9	2.9	2.5	3.4	2.5	33.3
Wilmington	3.9	3.9	3.4	2.7	4.5	4.8	3.9	4.5	3.6	4.1	3.6	4.5	47.4
Woodstock	2.91	2.84	3.18	2.75	3.48	3.31	3.78	3.49	3.57	2.81	3.12	2.88	38.12

THE GAS PRODUCER PLANT FOR WATER PUMPING AT MANCHESTER, MASS.

(A RECORD OF TWENTY YEARS.)

BY RAYMOND C. ALLEN.*

[*Read November 14, 1928.*]

In 1909, the town of Manchester on the North Shore of Massachusetts Bay, found itself obliged to secure an increased supply of water in order to properly satisfy the demands of its extensive summer colony and, at the same time, to provide increased pressure for adequate fire protection to estates that had been developed upon the higher hills of the town.

The need for more water was met by the acquisition of Gravel Pond, a great pond in the Chebacco Group situated in the adjoining town of Hamilton. In this decision the town was guided by the advice of the late Desmond FitzGerald. The years since have proved the wisdom of this action, for the town has never suffered any anxiety due to threatened water shortage, as this pond, together with the original driven-well supply, has abundantly met all needs.

The requirements for additional pressure were filled by constructing a 1-million gal. reinforced-concrete standpipe, 50 ft. in diameter and 72 ft. in height, with high-water level at elevation 275 above mean low water, the village proper being at an average elevation of 20 ft. above the same datum. This structure gave considerable trouble from leakage, and not until it was lined with an asphaltic membrane, protected by a brick wall, were these worries satisfactorily eliminated.

The original pumping system consisted of a duplicate installation of Blake duplex, compound, condensing engines with a normal capacity of 750 000 gal. per day against a total head of about 198 ft. This plant, installed under the direction of the late Percy M. Blake, had been in service for about 18 years and had given good service, but was wholly inadequate for the new demands.

Accordingly, the town, after considerable study, installed in its old driven-well station and at its new Gravel Pond station duplicate units consisting of Smith gas producers, Nash gas engines, and Gould vertical triplex pumps; the units at the old station each being of 50-h.p. and 750 000-g.p.d. capacity, and those at Gravel Pond each being of 65-h.p. and 1-m.g.d. capacity.

This installation was described by the author before this Society in January, 1911.

After nearly twenty years, the equipment at the old or Home Station,

*Civil Engineer, Manchester, Mass.

which has had continuous use, began to present manifestations that called for remedial action.

The gas engines had been kept in very good condition, but the cylinders had been rebored until further efforts in this direction became unsafe, and the general wear was such that further repair was unwarranted. In like manner the producers seemed to have reached a like state, and the labor item, of more importance than twenty years earlier, was increasing.

The pumps were in remarkably good condition, and it was decided to retain them and install an electric drive. This has been done; the two units at the old station being belt-connected to 50-h.p., 1 200-r.p.m. General Electric motors, the reduction to the pinion gears of the pump of 270 r.p.m. being, in our opinion, thus most safely effected. The plant at Gravel Pond, having had much less wear than the Home Station, will probably continue to serve for some years without change.

In laying aside this producer unit it seems fitting to review briefly its performance for nearly two decades; such is the purpose of this paper.

The cost of the plant, in round numbers, in 1910 was as follows:

2 — 50-h.p. producers	$3 000
2 — 50-h.p. engines	5 500
2 — 750 000-g.p.d. pumps	4 100
	$12 600

As the pumps are being retained while the motive power is being discarded, the items laid aside amount to $8 500. The cost of the present electric installation replacing them has been about $6 800.

The producers were designed to use either bituminous coal or anthracite, but our experience led us to confine our use to pea and buckwheat coal, as we found the caking of the fire with soft coal too burdensome. Moreover, it was more difficult to get a cool, clean gas at the manifold of the engine.

The operation of the cleaning or scrubbing devices we found most important, and changes from time to time were made as improvements in equipment became available or as need required.

At the early period of producer use, some difficulty was experienced in safeguarding the operators against carbon monoxide poisoning, and perfect ventilation was found to be essential.

During operation of the plants, all discharge through the stack or chimney to the outer air is closed by shutting a "stand-over" valve which must be opened when the engine is stopped. Constant watchfulness is necessary in this respect. Some four years after installation, the plant at Gravel Pond was burned by a gas explosion which, in all probability, was caused by an accumulation of gas from a closed "stand-over" pipe. No material damage was done to the pumping equipment, but the station required a new roof.

The gas engines were started by air pressure and were furnished with Bosch magnetos and storage batteries for ignition. They gave very little trouble in their regular operation. From time to time, however, the cylinders required reboring, and new parts had to be provided. During the last few years, it has been necessary to have new parts made as needed, thus adding to delay and expense.

The pumps have given no trouble and appear to be in nearly as good condition today, as when installed.

At the Home Plant, tests on installation indicated a duty of 150 million ft.-lb. per 100 lb. of coal on full-time operation.

The records of operation for the period since installation are abstracted in the accompanying table. The basic data are not always consistent, but do show the actual performance of the plant during its life.

The table reflects several interesting facts among which should be noted:

1. The fact that the daily runs were short and the "stand-over" periods long is shown by the amount of coal consumed and the duty values obtained.

2. The cost of coal rose continually. Under war conditions and labor difficulties, it became nearly three times that of the first years.

3. The cost of labor increased nearly three times over that of the first period. This is due partly to normal increase in labor wages and also to the allocation of maintenance labor on the distributing system to pumping operations. This is not an ideal situation, but is not unknown in public-works affairs. The men must be kept organized as an emergency crew and the cost is a proper charge against the whole system; but not against the pumping plant. I should estimate that in the last ten years perhaps one third of this labor cost is due to this allocation.

4. Cost of unusual repairs, while not excessive, represents about 32 per cent. of the original investment and is in addition to normal wear and tear.

5. Cost per million gal. raised one ft. shows a gradual increase for nine years from 15 cents to 24 cents and a greater increase in 1927 to 45 cents.

In conclusion the experience at this plant has, on the whole, been very satisfactory. The work has been done at a reasonable cost and at all times reliably.

Under the conditions existing at the time of its installation, it appears that a reasonably good investment was made.

RECORD OF PLANT PERFORMANCE AND COST OF OPERATION, 1911–1927.

Year.	Coal used, tons.	Water pumped, million gal.	Duty, million ft.-lbs. per 100 lb. coal.	Cost (dollars).				
				Coal.	Labor.	Total including oil and repairs.	Unusual repairs.	Per million gal. raised 1 ft.
1911	72.187	53.952	82.6	441.98	1 252.32	2 094.94	....	.15
1912	69.087	55.475	88.5	531.37	1 489.84	2 659.43	....	.18
1913	83.099	64.895	86.0	580.68	1 783.32	3 320.81	420.55	.19
1914	92.200	77.539	92.4	666.74	2 040.44	3 407.15	272.70	.17
1915	94.530	73.116	85.0	605.49	2 167.70	3 484.53	....	.18
1916	102.422	88.216	86.0	870.73	2 461.61	4 329.70	682.71	.19
1917	71.971	48.580	74.0	652.02	2 274.30	4 203.04	821.75	.33
1918	64.240	46.883	80.0	761.80	2 075.79	3 167.57	....	.26
1919	83.490	72.048	96.0	970.17	3 127.30	4 651.47	230.00	.24
1920	77.322	58.624	83.5	1 405.77	3 290.79	6 249.36	670.98	.41
1921	61.798	42.522	70.5	1 138.91	2 492.58	4 148.61	....	.38
1922	64.382	43.503	74.5	692.69	2 313.82	3 778.91	349.63	.33
1923	67.012	49.780	81.6	1 344.63	2 361.57	4 317.88	....	.33
1924	99.142	53.071	59.0	1 151.89	2 475.89	4 522.65	....	.33
1925	75.313	35.178	51.6	1 529.46	2 430.62	4 699.97	....	.51
1926	100.952	47.806	62.5	1 174.40	2 719.75	4 825.57	505.57	.38
1927	96.620	45.910	52.5	1 451.15	3 206.68	5 516.39	....	.45

DECOLORIZATION BY STORAGE IN CLEAN-BOTTOMED RESERVOIRS.

BY KARL R. KENNISON.*

[*Read November 14, 1928.*]

The purpose of this paper is to record the pertinent facts in the case of certain notable examples of the reduction in color of water due to storage in reservoirs. I have on various occasions attempted to collect and interpret data of this sort and have found it difficult to locate examples that delimit clearly the color-reducing effect of such storage. It is fairly well established that the bleaching effect of storage in reservoirs reduces the color to a considerable extent; and this paper is justified only because, in addition to confirming this fact, it presents the data in certain cases in which the effects of all extraneous influences are reduced to a minimum, so that the effect of bleaching alone during storage stands out very significantly and its extent is well defined.

To secure such ideal conditions, it is necessary first that the storage basin should be large in relation to the natural inflow into the basin for the period during which the reduction in color is observed, so that the color of the water is little, if at all, affected by that of the inflow into the basin. Furthermore, the bleaching effect is more clearly shown if the basin has a clean bottom, so that coloring matter is not absorbed therefrom. Furthermore, the reduction in color is more easily studied and interpreted if the color is as high as possible at the start of the period of observation. However, such a condition is rarely found in a clean-bottomed reservoir.

I have selected two notable examples in which the conditions happen to be very favorable for observation of the effect of bleaching or color reduction due to storage alone with a minimum effect of other factors. Both are clean-bottomed reservoirs, one an artificial reservoir that was cleaned during construction, and the other a natural lake. The first examples are observations on the Wachusett Reservoir of the Metropolitan District Commission, where it has been possible to select, in four recent years, periods, extending each for several months' time, in which the natural yield of the watershed was very low so that, commencing with a fairly accurate determination of the color of the water in the basin as a whole at the beginning of these dry periods, the reduction in color can be noted throughout these periods as representing closely the bleaching effect only. The second examples are observations on Suntaug Lake in the towns of Lynnfield and Peabody, which is a part of the water-supply system of the city of Peabody, serving as a storage basin for water pumped into the lake from other sources, principally from the Ipswich River Pumping Station of the city of Lynn.

*Designing Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

The drainage area naturally tributary to the lake is so small as to have no appreciable effect on the observations, and the color of the water pumped into the lake is so high that the conditions for observing its reduction have been rather unique. This fact has led the State Department of Public Health to take, for a time, more samples for analysis than would be the case in its ordinary routine of examining public water supplies.

WACHUSETT RESERVOIR.

Taking first the case of the Wachusett Reservoir, the drainage area is about 108.8 sq. miles, of which about 99.1 sq. miles are land area and 9.7 sq. miles are classed as water area including 6.5 sq. miles of water area constituted by the reservoir itself when full. The basin has a capacity of 64 970 million gal. to the flow line at elevation 395, as shown in Table 1,

TABLE 1.
CAPACITY AND AREA OF WACHUSETT RESERVOIR.

Draft below high-water level, ft.	Surface elevation, ft.	Draft, million gal.	Total storage, million gal.	Area, acres.
18-in. flashboards	396.5	0	67 000	4 184
12-in. flashboards	396.0	680	66 320	4 168
6-in. flashboards	395.5	1 360	65 640	4 150
0	395	2 030	64 970	4 135
1	394	3 380	63 620	4 102
2	393	4 710	62 290	4 068
3	392	6 030	60 970	4 037
4	391	7 340	59 660	4 006
5	390	8 640	58 360	3 964
6	389	9 920	57 080	3 923
7	388	11 200	55 800	3 899
8	387	12 460	54 540	3 854
9	386	13 700	53 300	3 764
10	385	14 910	52 090	3 674
11	384	16 100	50 900	3 624
12	383	17 280	49 720	3 590
13	382	18 440	48 560	3 526
14	381	19 570	47 430	3 446
15	380	20 680	46 320	3 370
20	375	25 850	41 150	3 305
25	370	30 550	36 450	2 768
30	365	34 890	32 110	2 564
35	360	38 900	28 100	2 360
40	355	42 600	24 400	2 190
50	345	....	17 700	1 930
60	335	....	11 900	1 605
	Bottom	....	0	0

TABLE 2.

WACHUSETT RESERVOIR — FLUCTUATION OF QUANTITY AND COLOR DURING MONTHS OF LOW SUMMER AND FALL INFLOW.

Period.	Elevation water surface, ft.	Total storage, million gal.	Average color,* p.p.m.	Surface color,† p.p.m.	Yield (million gal.).		Draft, million gal.
					Land area.	Water area.	
June to October 1923 inclusive	395.0 383.3	64 970 50 080	20	13 5	6 720	—1 460	20 150
June to November 1924 inclusive	396.1 382.7	66 460 49 370	21	15 2	6 590	—1 670	22 010
June 1924 to January 1925 inclusive	380.2	46 540	..	2	1 930	+460	5 220
June to October 1925 inclusive	384.9 370.9	51 970 37 270	15	10 1	6 200	—850	20 050
June to December 1926 inclusive	383.0 364.8	49 720 31 950	22	15 0	10 830	—760	27 840

*Surface at dam; bottom at dam; upper end of reservoir.
†At dam.

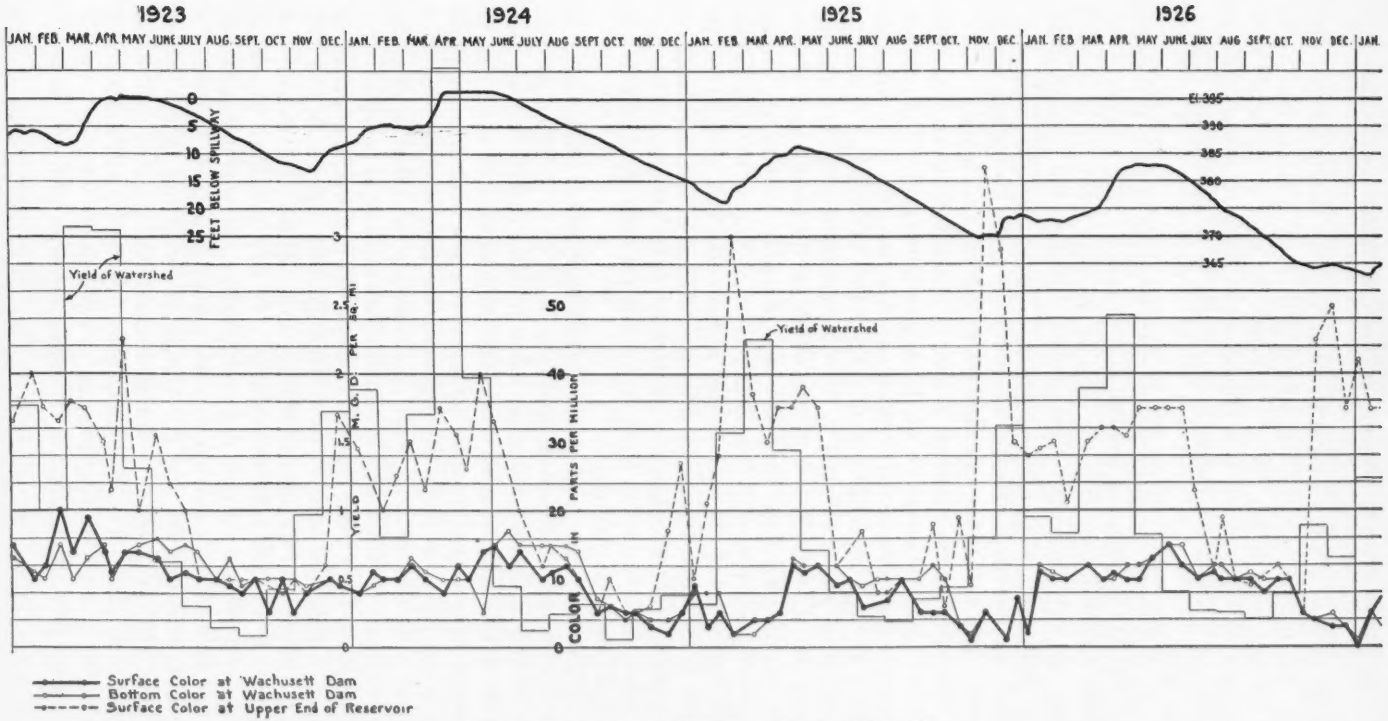


FIG. 1. — WACHUSETT RESERVOIR COLOR, 1923–1926.

and has an area of 4 135 acres at this flow line. In each of the four years from 1923 to 1926 inclusive the natural yield of the drainage area during the summer months was low and although the color of the water never reached a very high figure, as is typical of this basin, its reduction during the summer months was distinctly observable as to amount and approximate rate.

Table 2 shows the quantities of water involved in these periods and the colors at the beginning and end of each period. Fig. 1 shows in convenient graphical form how the color at different points of observation varied, not only throughout these periods of drought but throughout the entire four years 1923 to 1926 inclusive. The rise and fall of the water level of the reservoir is indicated across the top of the hydrograph and the monthly total yield of the watershed is also plotted on the graph.

The extent of the reduction in color is undoubtedly greater than that indicated by the observations at the dam or outlet end of the reservoir, since at the end of the period of spring high flows the color at the upper end of the reservoir is much higher than at the outlet. Over 80 per cent. of the total drainage area is tributary to the color observation station designated "upper end of reservoir." Furthermore, by far the greater bulk of water in the basin is stored near the outlet end. Roughly speaking, the average color would be represented more nearly by an average of the observations at the upper end of the reservoir and at the outlet end, giving twice the weight to the latter or, say, an arithmetic average of the observations at the upper end, at the surface near the dam and at the bottom near the dam, the latter two observations being very nearly the same at all periods with which we are here concerned.

As shown in Table 2, during the period from June to October inclusive, 1923, the amount in storage dropped from about 65 to 50 billion gal. with only about a little over 5 billion gal. inflow from the natural drainage area, and the surface color recorded at the dam dropped from 13 to 5 p.p.m. or, obtaining an average of the color in the reservoir as a whole from the beginning of the period as previously explained, the color dropped from 20 to 5 p.p.m., a decrease of 75 per cent., approximately equivalent to a cumulative percentage reduction from month to month of about 24 per cent. During the period from June, 1924 to January, 1925 inclusive, the amount in storage dropped from about 66 to 46 billion gal. with only a little over 7 billion gal. inflow from the natural drainage area, and the color dropped from 21 p.p.m. to a nearly colorless condition. In fact, it reached this nearly colorless condition at the dam two months earlier, the color during December and January being affected by a late fall inflow of fairly high color, as shown on the hydrograph (Fig. 1). During the period from June to October inclusive, 1925, the amount in storage dropped from about 52 to 37 billion gal. with only a little over 5 billion gal. inflow from the natural drainage area, and the color dropped from 15 p.p.m. to a practically colorless condition. During the period from June to December inclusive, 1926, the amount in

storage dropped from about 50 to 32 billion gal. with only about 10 billion gal. inflow from the natural drainage area, most of that coming near the end of the period without time to affect the color at the dam. Meanwhile the color dropped from about 22 p.p.m. to a practically colorless condition.

These reductions of color stand out on the hydrograph very significantly and clearly and, in spite of the fact that there was considerable natural inflow into the reservoir during the period of observation of the reduction, the hydrograph tends to show that the low color recorded at the dam is not affected by the late fall and winter inflow, until the end of each of the periods referred to, at least until the first of December.

Furthermore, the trend or rate of reduction is fairly distinct in spite of the fact that the color at the beginning of the period is in no case what would be called a high color.

SUNTAUG LAKE.

In the case of Suntaug Lake, however, we have a still more favorable condition for such observations. The drainage area of the lake is about 0.57 sq. mile, of which only about 0.32 sq. mile is land area above the flow line of the lake when full. The surrounding ground, however, is very porous, and it has been possible to determine from fairly accurate measurements that there is considerable ground-water storage in addition to the visible storage, the amount going into ground-water storage when the lake is filled being nearly, but not quite, offset by that drained out when the lake is drawn down, there being a noticeable lag in the flow of this ground water and undoubtedly some net loss outside the drainage area. An accurate survey of the bottom, the installation of a rain gage at the lake throughout the periods of observation and meter records of the pumpage make it possible to determine all the quantities involved very accurately. However, I have purposely avoided burdening this paper with the details of computations.

The basin has a capacity of 812 million gal. to the flow line at elevation 117, as shown in Table 3, and has an area of 158.5 acres at this flow line. The lake which, by the way, is one of the familiar beauty spots along the Newburyport Turnpike, is shaped somewhat like a round bowl, 3 000 ft. in diameter and 17 ft. deep, except for a considerably deeper hole near the outlet, and the color is fairly well distributed at all times. The end of the pipe line, which supplies the lake with highly colored water from the Ipswich River Pumping Station of the city of Lynn, and the location of the tunnel intake, where the water is drawn off into the Peabody supply, are on approximately opposite sides and separated by a small peninsula.

The intermittent fillings of the lake with highly colored water and bleaching between fillings are given in Table 4, and the entire information is presented graphically in Figs. 2 to 5, which show with a considerable degree of precision the quantities added to and drawn from the lake, the

color of the water and the rise and fall in the lake level and also in the level of Spring Pond, which is the principal source of supply for Peabody, especially during the intervals when there is no draft from Suntaug Lake.

The variation in daily rainfall is also shown along the top of the hydrograph sheets (Figs. 2 to 5), and also the weather condition, *i.e.*, whether the day was fair or cloudy. I have made an attempt to find, if possible,

TABLE 3.

CAPACITY AND AREA OF SUNTAUG LAKE.

Draft below high-water level, ft.	Surface elevation, ft.	Draft, million gal.	Total storage, million gal.	Area, acres.
0	El. 117	0	812	158.5
1	116	52	760	156.5
2	115	103	709	154.1
3	114	153	659	151.5
4	113	202	610	148.1
5	112	250	562	144.8
6	111	296	516	141.3
7	110	341	471	138.0
8	109	385	427	133.7
9	108	428	384	129.5
10	107	469	343	124.8
11	106	508	304	120.0
12	105	...	265	115.5
13	104	...	228	109.5
14	103	...	193	103.5
15	102	...	160	96.5
16	101	...	130	87.4
17	100	...	104	66.5
18	99	...	90	31.5
19	98	...	80	26.6
21	96	...	64	23.3
23	94	...	49	20.9
	Bottom	...	0	0

some relation between the rate of bleaching and the number of sunny days, but was unsuccessful in the attempt. I have, however, included all these data in the hydrograph for the benefit of anyone who may wish to make use of them.

On December 11, 1925, the lake contained 500 million gal. of practically colorless water, the average of several readings, over a considerable period of time previously, being about 3 p.p.m. Between that date and January 23, 1926, 466 million gal. were pumped into the lake, the new supply being so highly colored that the resulting total in storage had a color of about 60 p.p.m.

Between January 23 and April 30, the quantity in storage remained

TABLE 4.

SUNTAUG LAKE — FLUCTUATION OF QUANTITY AND COLOR.

	Elevation water surface, ft.	Total storage, million gal.	Surface color at outlet, p.p.m.	Water added by pumping, million gal.	Period of Observing Color Reduction Between Intervals of Pumping.			
					Natural Yield (million gal.).			Draft, million gal.
					Land area.	Water area.	From ground storage.	
1925								
December 11	110.65	500	3					
1926				466				
January 23	115.45	732	60					
					50	+21	−10	51
April 30	115.65	742	25					
				94				
May 17	117.05	815	37					
					45	−24	+130	666
1927								
January 23	105.9	300	9					
				655				
March 10	116.75	799	75					
					34	−8	−4	137
May 15	114.5	684	44					
				250				
June 6	117.25	825	75					
					54	+13	+76	528
1928								
January 18	109.3	440	21					

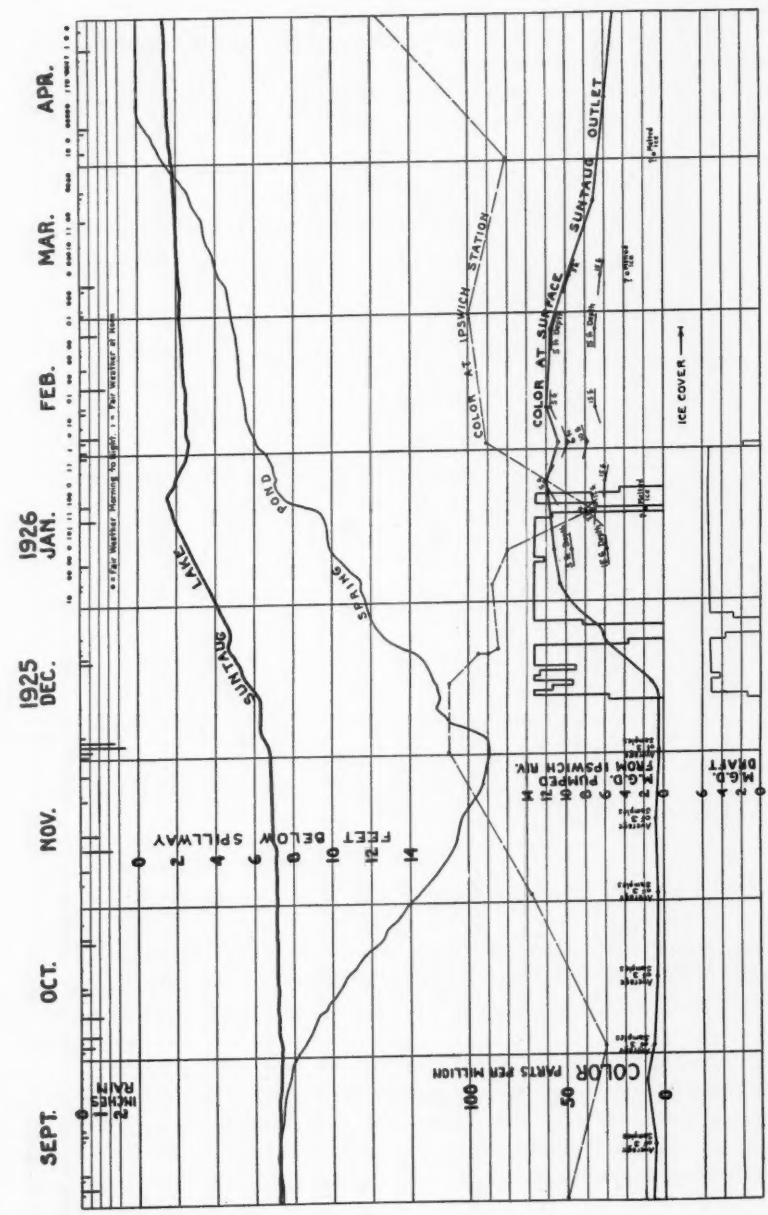


FIG. 2.—SUNTAUG LAKE COLOR, SEPTEMBER, 1925 TO APRIL, 1926.

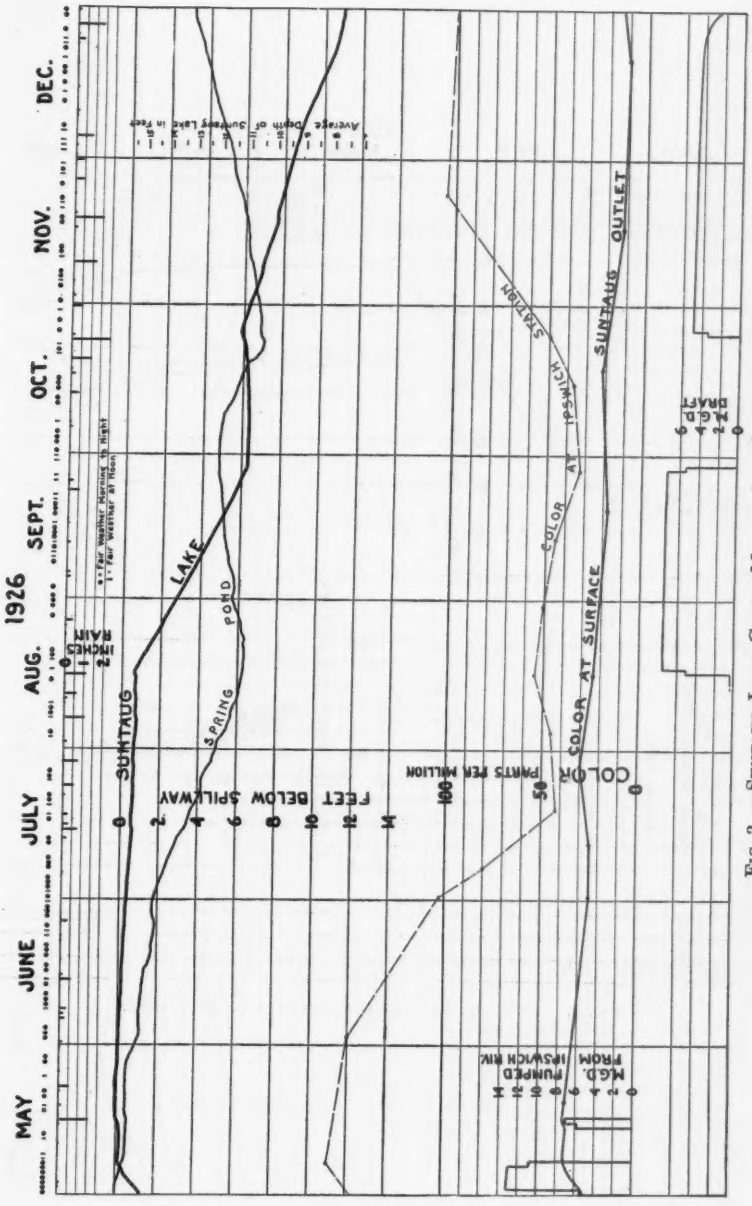


FIG. 3. — SUNTAUG LAKE COLOR, MAY TO DECEMBER, 1926.

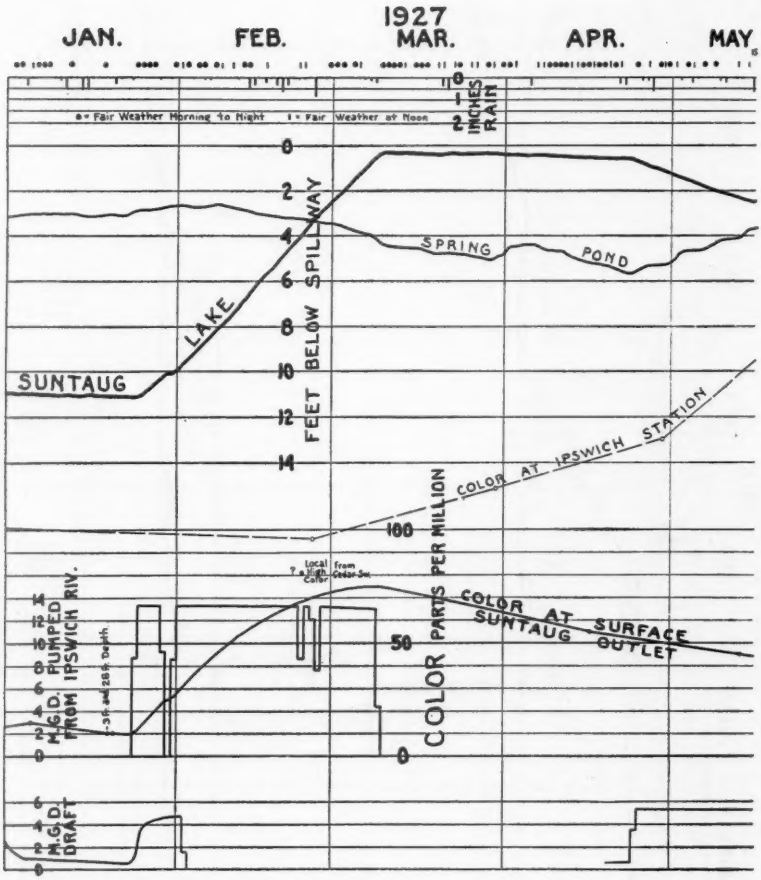


FIG. 4. — SUNTAUG LAKE COLOR, JANUARY TO MAY, 1927.

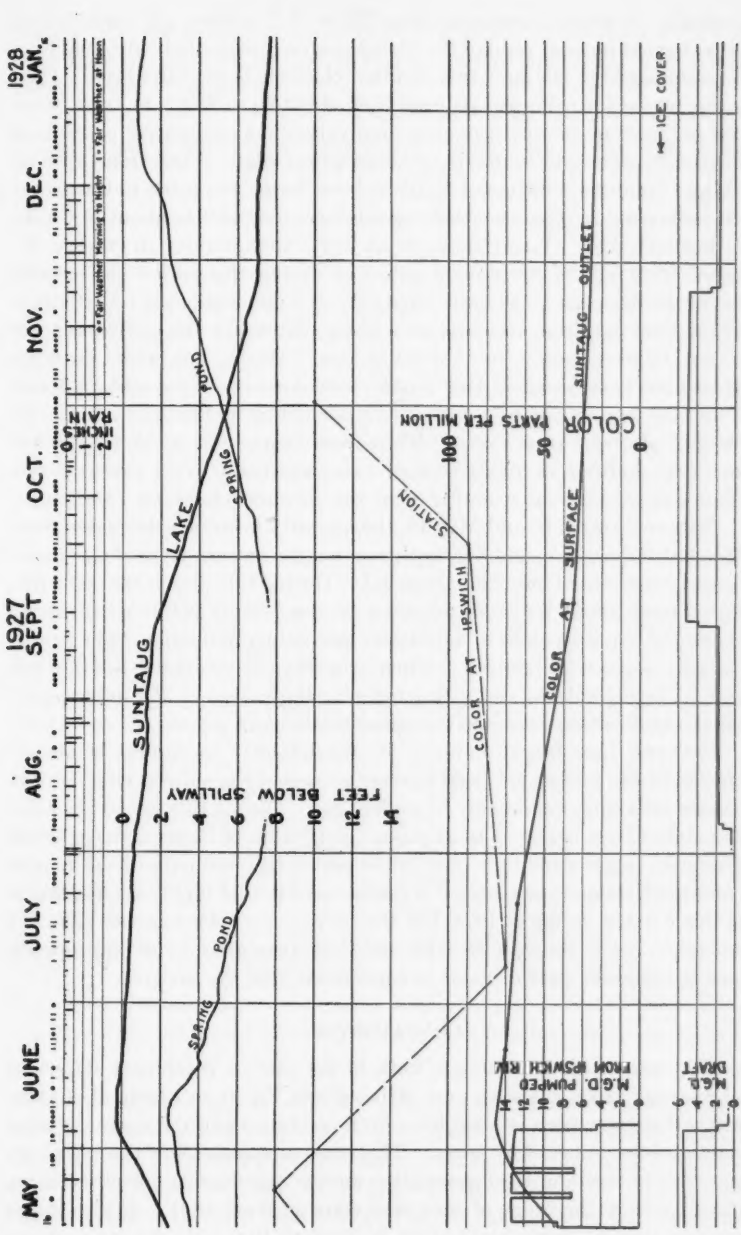


FIG. 5.—SUNTAUG LAKE COLOR, MAY, 1927 TO JANUARY, 1928.

practically constant, increasing from 732 to 742 million gal., and during this period the natural yield of the drainage area contributed only 71 million gal., counting both the land area and the relatively large water area. During this period the color was reduced from about 60 to 25 p.p.m., a decrease of 58 per cent. in about 3.2 months, equivalent to a cumulative percentage reduction from month to month of about 24 per cent. Then from April 30 to May 17 another addition of highly colored water was made to the extent of 94 million gal., so that the resulting color was increased to about 37 p.p.m.

Between May 17 and January 23, 1927, the quantity in storage decreased from 815 to 300 million gal., and during this period the natural yield of the drainage area contributed only 21 million gal., the contribution of 45 million gal. from the land area being reduced in this period over 50 per cent. by evaporation from the water area. During this period the color was reduced from about 37 to 9 p.p.m., a decrease of 76 per cent. in about 8.2 months, equivalent to a cumulative percentage reduction from month to month of about 16 per cent. Then from January 23 to March 10, another large addition of highly colored water was made to the extent of 655 million gal., so that the resulting color was increased to about 75 p.p.m.

Between March 10 and May 15, the quantity in storage decreased from 799 to 684 million gal., and during this period the natural yield of the drainage area contributed only 26 million gal. During this period the color was reduced from about 75 to 44 p.p.m., a decrease of 41 per cent. in about 2.2 months, equivalent to a cumulative percentage reduction from month to month of about 22 per cent. Then from May 15 to June 6, another addition of highly colored water was made to the extent of 250 million gal., so that the resulting color was increased to about 75 p.p.m.

Between June 6 and January 18, the quantity in storage decreased from 825 to 440 million gal., and during this period the natural yield of the drainage area contributed only 67 million gal. During this period the color was reduced from about 75 to 21 p.p.m., a decrease of 72 per cent. in about 7.4 months, equivalent to a cumulative percentage reduction from month to month of about 16 per cent. A further addition of highly colored water was made in the spring of 1928, but the samples for color analysis have not been taken since January 18 with sufficient regularity or at appropriate times to make the data of value in connection with this analysis.

CONCLUSIONS.

The rate of color reduction, both in the case of Wachusett Reservoir and Suntaug Lake, is shown very strikingly in Fig. 6, in which all of these periods that have been studied have been combined and the curves of color reduction superimposed by years. This chart also shows how the extremely high color in Suntaug Lake presents a unique opportunity for observation entirely outside the range of such reservoirs as Wachusett. It also shows how data such as were obtained for Wachusett Reservoir, which in themselves do not show a sufficiently high color to present distinct results as to

the rate of color reduction, fit very nicely into data such as those for Suntaug Lake so that the two series taken together indicate a very definite trend or rate of reduction.

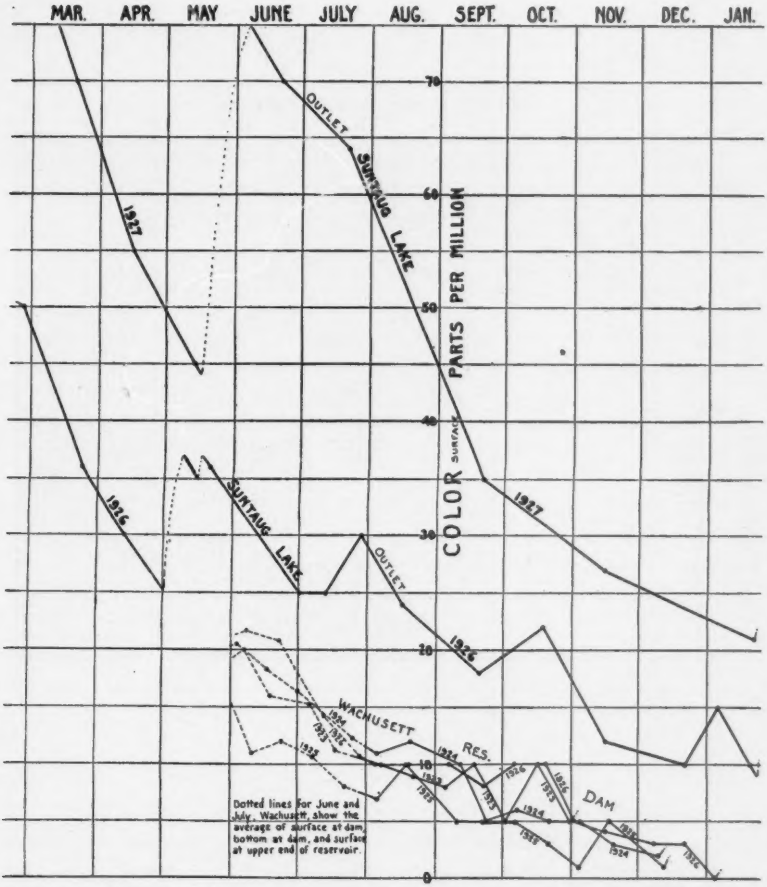


FIG. 6. — RATE OF COLOR REDUCTION, WACHUSETT RESERVOIR AND SUNTAUG LAKE.

I find that this can be well expressed as a percentage reduction in the color and that this percentage seems to be about 20 per cent. every 30 days. The Wachusett graphs would indicate a lower figure, possibly 15 per cent., when the color has been reduced to less than about 20 or 25 p.p.m., but it should be borne in mind that the color in Wachusett Reservoir is replenished by inflow even during a dry summer to a greater extent than in Suntaug Lake where more ideal conditions for such observations on the re-

duction by storage exist. Hence I conclude that 20 per cent. reduction of color every 30 days well expresses the results obtained.

In closing I wish to acknowledge with thanks the coöperation of the Massachusetts Department of Public Health in making available its records of the analyses of the water, rainfall, etc., and also the coöperation of the City Engineer of the city of Peabody for furnishing much valuable information.

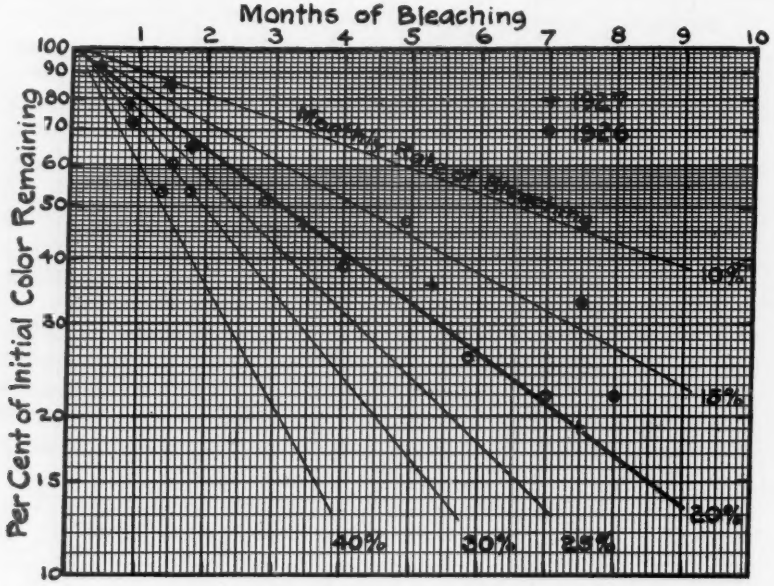


FIG. 7.—MONTHLY RATE OF COLOR REDUCTION IN SUNTAUG LAKE AS INDICATED BY SEMILOGARITHMIC PLOTTING OF KENNISON'S DATA FOR 1926 AND 1927.

DISCUSSION.*

GORDON M. FAIR.†‡ The author's analysis of color observations on Suntaug Lake and Wachusett Reservoir show clearly that decolorization of clean-bottomed reservoirs follows the so-called "die-away curve" and can be formulated as follows:

$C_t = C\ (1 - r)^t$, where

t = the time in months

C_t = the color remaining after t months

C = the color at the beginning of the period

r = the monthly rate of decolorization = $\frac{p}{100}$, where

p = the monthly percentage rate of decolorization.

*Editor's Note: A discussion of this paper by Caleb M. Saville will appear in the June, 1929 JOURNAL.
†Assistant Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.
‡By letter.

The observations should, therefore, yield a straight line when plotted on semilogarithmic paper. That the data for Suntaug Lake do so quite closely is shown in the accompanying diagram. Substituting the author's suggested rate value of 20 per cent. in the formula, we have $C_t = C \times 0.8^t$.

It is interesting to note that this die-away curve is encountered in a number of other instances of interest to the water-works engineer. Among them may be mentioned: the decolorization of impounding reservoirs in the years following their initial filling; the natural decrease of pollutional bacteria during the storage of water; the artificial destruction of bacteria by disinfectants; and the reduction in biochemical oxygen-demand of polluted water.

Chemists would speak of decolorization as a "unimolecular reaction," the equation of which would probably be stated as $\frac{C_t}{C} = 10^{-kt}$ where k = the decolorization constant. For a rate of color reduction of 20 per cent. per month, $k = 0.1$ approximately.

PROCEEDINGS.

November Meeting.

Boston City Club, Boston, Mass.

Wednesday, November 14, 1928, 2 p.m.

President Arthur D. Weston in the chair.

The President announced the election of the following members: Benton W. Vaughan, Everett, Mass.; Donald W. Foster, North Wilmington, Mass.; Bayard F. Snow, Engineer in charge of South Essex Sewerage District, Salem, Mass.; Charles Thomas Gilliard, Superintendent, Water Works, Andover, Mass.; John J. Devlin, Engineering Assistant to President of Manning, Maxwell & Moore, Inc., New York; Reginald L. Reed, Assistant Engineer, Hydraulic Development Company, Boston.

Corporate Member.

Town of Hudson, Mass.

The President. In order to devote more time and attention to the superintendents, the papers will, in the future, be limited to an hour, including discussion. We shall thus have about an hour and a half for a round table discussion with the superintendents.

We shall not know what subjects to bring before the superintendents unless they themselves make their wishes known. I shall appreciate it, if anyone who has a subject he wants discussed will write to Robert Spurr Weston, Chairman of the Program Committee, who will give the subject a place on the program.

A paper on "Decolorization by Storage in Clean-bottomed Reservoirs," illustrated by stereopticon slides, was read by Karl R. Kennison, Designing Engineer, Metropolitan Water Supply Commission, of Boston. Messrs. Caleb M. Saville, Gordon M. Fair, Dwight Porter and Robert Spurr Weston took part in the discussion.

A paper on "The Gas Producer Plant for Water Pumping at Manchester, Mass. (A record of 20 years)," was read by Raymond C. Allen, Civil Engineer, Manchester, Mass. Samuel A. Agnew discussed the paper.

A Superintendents' Round Table Discussion then took place at which the following subjects were considered:

What is to be done regarding charging betterment assessment for water main extensions?

What practice is to be adopted for cleansing new mains to prevent pollution of the water supply when a new main is placed in service?

What is the best method of backfilling trenches, — with or without water?

These subjects were discussed by George C. Brehm, Allen M. Symonds, Samuel H. MacKenzie, Henry V. Macksey, David A. Heffernan, A. R. Hathaway, Charles W. Sherman, Benton W. Vaughan, Hervey A. Hanscom, Donald W. Foster, Gordon M. Fair, George H. Finneran, E. Sherman Chase, H. O. Lacount, Roger W. Esty, Morrison Merrill, Henry T. Gidley, and Charles J. Crump.

(*Adjourned.*)

December Meeting.

Boston City Club, Boston, Mass.

Wednesday, December 12, 1928.

The President, Arthur D. Weston, in the chair.

The President announced the election, at the Executive Committee meeting of December 12, 1928, of the following new members: James V. Turner, East Providence, R. I.; Harold F. MacWilliams, Newburyport, Mass.; James A. Hancock, Framingham, Mass.; Emil A. Ekern, Winchester, Mass.; Walter E. Rundlett, Watertown, Mass.

The President. I am sorry to have to announce that since our last meeting we have lost one of the most popular members of the New England Water Works Association. I refer to our past president, George W. Batchelder, of Worcester. I would like the members to stand for just a moment in tribute to Mr. Batchelder's memory.

(*Everybody stands in silence.*)

A paper on "The Reforestation of the Watersheds of Winchester's Water Supply", was read by Charles E. Kendall, Water Commissioner, Winchester, Mass. Messrs. L. M. Hastings, Patrick Gear, Stephen H. Taylor, Edwin H. Arnold and Henry T. Gidley took part in the discussion.

The final report of the Committee on Cross-connections was presented by Robert Spurr Weston, Chairman of the Committee. A motion by Charles W. Sherman that the resolutions of the Committee be approved by the meeting and submitted to the membership of the Association was seconded by Henry V. Macksey and adopted after discussion by: Caleb M. Saville, M. N. Baker, Charles W. Mowry, Patrick Gear, Gordon M. Fair, Henry V. Macksey, Robert Spurr Weston, Arthur D. Weston, E. Sherman Chase, L. H. Kunhardt, Frank A. McInnes, Frank A. Barbour, George A. King, Charles W. Sherman and David A. Heffernan.

The balance of the meeting was taken up by a general discussion of subjects of interest to superintendents, Messrs. Richard H. Ellis, George C. Brehm, Henry A. Symonds, George H. Finneran, David A. Heffernan, Benton W. Vaughan, Allen M. Symonds and Harry W. Dotten taking part.

(*Adjourned.*)

JANUARY MEETING.

BOSTON CITY CLUB, BOSTON, MASS.

WEDNESDAY, JANUARY 9, 1929.

The President, Arthur D. Weston, in the chair.

The Secretary announced the election by the Executive Committee of the following members: Alfred Benson, Arlington, Mass.; Percy C. Charnock, West Medford, Mass.; Frank L. Flood, Needham, Mass.

Associate.

Anthony Ross & Son, Lexington, Mass.

A paper on "The New Storage Facilities of the Pawtucket Water Works" (illustrated), was read by Frederick Crawford Williams, City Engineer, Pawtucket, Rhode Island. Messrs. Byron I. Cook and L. M. Hastings took part in the discussion.

A paper on "Municipal Water Works for the Town of Marshfield, Mass.", prepared by Henry A. Symonds and Fred O. Stevens, Consulting Engineers, Boston, was read by Mr. Symonds. Messrs. Dwight Porter, Henry T. Gidley, Robert Spurr Weston, W. P. Mosteller, David A. Heffernan, Mr. White, and Allen M. Symonds took part in the discussion.

The matters of pending legislation and of collection of bills through shutting off of water, were discussed by George C. Brehm, Benton W. Vaughan, Henry V. Macksey, George A. King, William Naylor, Henry F. Hughes, David A. Heffernan and Frank L. Northrop.

(*Adjourned.*)

FINAL REPORT OF COMMITTEE ON CROSS-CONNECTIONS.

[Presented December 12, 1928.]

PREFACE.

Since the presentation of the Committee's report at the March meeting of the Association, the subject of cross-connections has been discussed widely, and considerable new information has been obtained.

First in importance, is the invention of a chlorine applicator adapted for auxiliary fire pump supplies as well as for other supplies that are held in reserve. A description of this apparatus is given in Appendix H of the report.

The new apparatus discharges a small amount of chlorine to waste continuously, and when the fire pump is started or the fire supply is turned on the dose is automatically increased to one that is more than sufficient to disinfect the auxiliary supply. While the device is promising, your Committee believes that more experience must be gained with it before it can be recommended by this Association except in a tentative way.

Some recent results of inspection of cross-connections by the Connecticut State Department of Health have been added to those in the first report and are interesting, because they demonstrate the effectiveness of double check-valves of the modern type, when regularly inspected and tested.

The report has been discussed by various members of the Association and reconsidered by the Committee. It was on the program of the Convention in September and is the subject for discussion at the December meeting.

As a result of further consideration, some new material has been included in the report and revised resolutions have been drafted as given in the preliminary copies of the report distributed prior to the December meeting. The Committee submits the revised report and resolutions to the Association with the suggestion that the resolutions, either as presented or as modified in open meeting, be submitted to the members for a vote by letter ballot.

REPORT.

Mr. President and Members of the New England Water Works Association: The undersigned, having been appointed by you members of a Committee on Cross-connections, having held several meetings, and having collected many data, respectfully submit the following report:

Definitions. By a cross-connection is meant a connection between

the distribution system of a public or private, potable water supply and a private or secondary, non-potable water supply.

One common example of a cross-connection is that between the public water supply of a municipality and the auxiliary fire-hydrant or sprinkler supply of a mill or factory,— the former sufficing for ordinary uses and the latter for fire fighting only. Another frequent case is where under ordinary conditions the public supply is taken for drinking purposes and for use in toilets and lavatories only,— water for all other purposes being taken from the secondary industrial supply. In a third common instance, water for various industrial processes, including boiler-feed water, as well as drinking water and water for toilets and lavatories, is taken from the municipal source, leaving the industrial source for private fire supply and miscellaneous industrial uses. For a more extended classification of cross-connections see Appendix A.

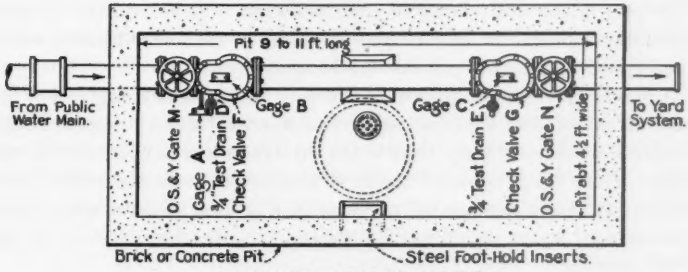
Connections are usually made through piping and gate-valves, with or without accompanying check-valves. Check-valves vary in type from simple, single, iron check-valves, with a swinging clapper, operating against an unfinished iron seat, to elaborate double, bronze, check-valves, like those devised and specified by the Associated Factory Mutual Fire Insurance Companies. The former are not precisely machined to prevent leakage, are usually rendered inaccessible by being buried in the ground, and are liable to rust so that the free movement of their clappers is obstructed. The latter are of excellent workmanship, are usually set in pits, or where they are accessible for inspection at all times, and are built of non-corroding bronze with rubber-on-bronze seats. This type of valve is equipped with gages and test cocks. (See accompanying figure.)

The Demand for Cross-connections. The principal demand for the establishment of cross-connections comes from fire insurance companies and from property owners who desire two rather than one source of water supply in order that there may be additional protection to life and property. Opposition to cross-connections has come principally from the health and water-works authorities, largely because numerous epidemics of disease have been traced to these connections.

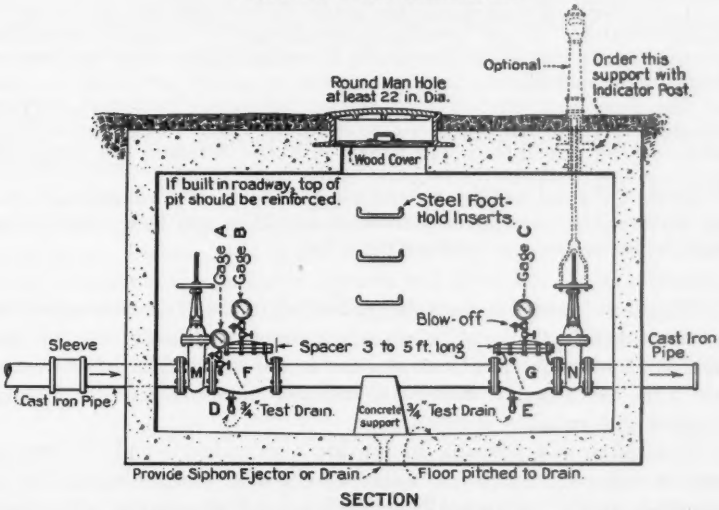
Industrial Use. Many large industrial plants and public utilities require a constant supply of water for boiler feed, for cooling purposes and for various manufacturing processes. To insure continuous operation, some secondary standby supply, instantly available in emergency, must be provided.

It is usually prohibitive in cost to purchase public water for ordinary uses and at the same time to store a supply of potable water sufficiently large for probable emergencies. Some way of using both the public supply and a secondary supply when needed is a practical necessity.

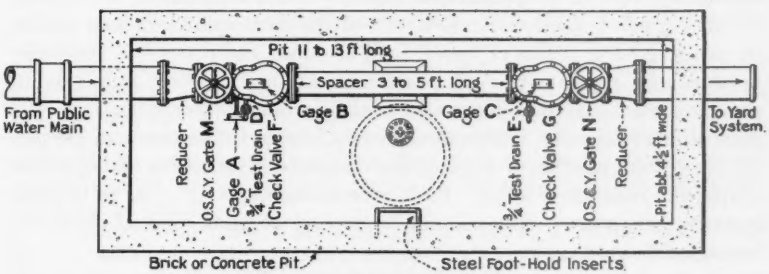
Fire Protection. The automatic sprinkler has made it possible to concentrate with safety enormous values in industrial plants, mercantile buildings and warehouses. The manufacturers of the country have utilized this



PLAN OF 6 INCH CONNECTION



SECTION



PLAN OF 8 INCH OR 10 INCH CONNECTION

6 INCH BRONZE CHECK VALVES WITH TAPER REDUCERS MAY BE USED IN 8 INCH CONNECTIONS AND 8 INCH BRONZE CHECK VALVES WITH TAPER REDUCERS IN 10 INCH CONNECTIONS.

DOUBLE CHECK-VALVE INSTALLATION RECOMMENDED BY THE ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES.

advantage to such an extent that adequate fire protection is now a necessity for the profitable continuance of their business. It is doubtful if the industrial development of this country could have been so extensive without the safeguarding influence of automatic sprinklers.

A good public water system is the very best primary supply for automatic sprinklers, and there is usually no practicable way of providing an alternative primary supply that is the equivalent of a good public water system. Even large elevated tanks storing water from the public supply and erected at great expense are necessarily of limited pressure and capacity. But municipal water supplies *alone* cannot be depended upon in all cases, for two reasons:

1. Fire will not wait in case the public water supply should happen to be out of service. If the tremendous advantages of automatic sprinklers in extinguishing fires *at the start* are to be realized, there must be pressure *always* on the sprinklers.

The Associated Factory Mutual Fire Insurance Companies have recorded about three hundred instances in which public water supplies have failed or been interrupted. In twelve of these instances fire broke out simultaneously with the interruption of the water supply.

2. Public water supplies are frequently *inadequate* in volume and pressure for the large number of automatic sprinklers and hose streams that might be needed to cope with a serious fire.

Therefore, whenever the value protected, or the fire or life hazard involved, is sufficiently great, a secondary supply is needed in order that automatic sprinklers shall control a fire at the start. The labor laws of New York State permit double the number of employees in buildings equipped with sprinkler systems.

It is often impracticable to provide a secondary supply of potable water of sufficient capacity to assure a volume of water adequate for an emergency, such as an unusually severe fire or a conflagration. Secondary supplies of non-potable water, however, can be obtained in sufficient volume by utilizing open bodies of water, such as ponds and rivers. A cross-connection is at present the only practicable method of combining existing potable public water systems and available non-potable secondary supplies of large capacity, both automatically feeding into a common fire protective system capable of meeting the demands of sprinklers and hydrants during the progress of a fire. Such cross-connections, in order to function instantly when fire occurs, cannot be dependent upon manual operation, but must be automatic.

Cross-connections and the Public Health. The following is a brief abstract of twenty-five instances on record where outbreaks of disease have been brought about by pollution of drinking-water supplies through cross-connections. Details of these occurrences are given in Appendix B.

In nineteen of these instances the cross-connection contained a single gate- or check-valve. It must be borne in mind that a gate-valve is not an

automatic device and that it affords no protection unless closed. In three instances, protection against mixing of unsafe with safe water was afforded by two gate-valves or by a check-valve and a gate in series, and in one instance there were two gate-valves and a check-valve in series on the cross-connection. In one instance, it might be assumed from the wording of the published record that protection against pollution was afforded by two gate-valves and a double check-valve arranged in series, although this was not definitely stated. In another case this condition was definitely stated. It is also true that one of the double check-valves that failed was of inferior type and that one had not been inspected recently.

In addition to the appended list of recorded cases of sickness or death due to pollution entering drinking-water systems through cross-connections with unsafe water supplies, the Conference of State Sanitary Engineers and several sanitary authorities have listed a considerable number of cases where trouble was caused by the introduction of polluted water through leaks in emergency intakes or by similar causes. The report of your Committee, however, is limited to the effect of cross-connections, important as the other sources of danger may be.

Position of the Public Health Authorities. While from the broad economic standpoint it may be undesirable to run the risk of fire losses and, possibly, some losses of life by accident to firemen and industrial employees in order to avoid the hazard of sickness and death due to the existence of cross-connections, the saving of life rather than of money must always be the dominant motive for sanitary authorities. The following may be given as examples of the reactions of sanitary authorities to this danger.

The position of New Hampshire is as follows:

"As a historical preface, it can be stated that this matter has been receiving consideration by the New Hampshire Board of Health for more than a dozen years. Attempts at reform had their inception when, as a result of some bad conditions discovered, a legislative bill was introduced which sought to prohibit the existence of any connection on a public water supply through which polluted water might be introduced therein.

"The opposition at the time of the industrial interests was so intensely manifested and the impossibility of establishing a flat prohibition was so obvious that this department next proceeded to consider the special safety devices that were then available. Manufacturers were advised that the situation involving single cast-iron check-valves, usually buried in the ground and commonly not even known to the water-works management, could not be permitted.

"A few of these manufacturers then proceeded to install special type double checks but most of them continued to 'stand pat,' or, while promising, to follow a procrastinating course. This they were able to do (1) because of the absence of any legislation and (2) because of the lack by this department of any adequate inspectional facilities.

"In 1919 a law was enacted in effect prohibiting the maintenance of a connection of this character, except such as might be approved by the state board of health. There was included a proviso that 'every valve, gate or other device for controlling or preventing the inflow of water of un-

approved character into the public supply shall be of such construction as to permit of efficient inspection and testing, and an actual test thereof shall be made not less than twice annually by the individual, corporation or association furnishing water to the public.'

"A beginning was then made toward the eradication of the single iron checks and manufacturers, in response to their inquiries, were advised that the least that could be accepted was the device as now commonly in use, suitably installed in a test pit. At the present time 67 New Hampshire mills have these double check connections.

"Although recognizing that the ideal situation is one involving no connection whatsoever between a public water supply and a polluted industrial source, yet, with us it is a case of doing the best thing possible in view of existent facts. While admitting that no such device affords an infallible means of protection, yet it also cannot be denied that no form of protective action against a polluted water supply can be said to be infallible, these depending, as all of them largely must, upon the human factor.

"Accordingly, it is the present policy of the New Hampshire Board of Health to permit, for the purpose of fire protection only, of the use, in lieu of mechanical severance, of a suitable connecting device of the best approved type, providing also that such be installed in a proper test pit, and maintained under periodic inspection."

In December, 1926, the Rhode Island State Board of Health, while without authority to prevent the installation and use of cross-connections, adopted a resolution advising that all such be abolished.

In its bulletin of January 1927, the Connecticut State Department of Health published an article by the Director of its Bureau of Sanitary Engineering. In this article, the author cites the regulations of the department, namely, that after December 31, 1926, no cross-connections shall exist between potable and non-potable supplies, except that installations protected by double check-valves of approved type with adequate facilities for testing that were in existence on December 31, 1926, may be temporarily continued, with the approval of the State Department of Health. The latter provision was inserted because it was felt that double check-valves of the latest approved type should be given a fair trial. The length of extension of time granted will depend upon investigations that the department is now making as to the efficiency of the newest types of valves. No new installations of double check-valves are allowed.

In New York State the Public Health Council of the State Department of Health adopted on November 12, 1925, an amendment to its sanitary code which prohibited cross-connections between non-potable and potable water supplies after July 1, 1926. This regulation permitted the continuance of cross-connections where two gate-valves with indicator posts and two check-valves of the special design of the Factory Mutual Fire Insurance Companies or equal were installed, but such connections were to be discontinued after July 31, 1928. The regulation also permitted the use of dual water-supply systems where the auxiliary supply was delivered to an elevated tank, provided the connections were made through an open discharge pipe above the high-water line of such tank.

On June 27, 1928, the Public Health Council voted to grant a further extension of six months. On July 3, 1928, the Commissioner of Health sent a letter to water-works authorities throughout New York State saying that, as a result of the development of a special fire-pump chlorinator, it was the opinion of the Department that the installation and proper maintenance of such a chlorinator would satisfactorily meet the requirements of the Sanitary Code. The letter further outlined certain conditions that were to be met prior to the approval by the Department of such cross-connections. Among these conditions was one calling for the proper installation of all-bronze, double check-valves between the fire-supply system and the municipal system. A copy of the letter is given in Appendix G.

In New Jersey a new chapter (Chap. XIII) to the Sanitary Code, enacted by the State Department of Health on September 18, 1928, reads as follows:

"Regulation 1: A physical connection shall be considered as any cross-connection, by-pass, valve, pipe line, auxiliary intake, or other similar device which permits or may permit any flow of water into an approved public potable water supply from any other water supply unapproved by the Department of Health of the State of New Jersey, or any source of water supply not fully treated in accordance with the terms of the provisions of the permit issued for or the rules and regulations governing the supplying of such water for public potable purposes by the Department of Health of the State of New Jersey.

"Regulation 2: That after April 1, 1929 physical connections shall not be permitted, except where such physical connections existing on April 1, 1929, include two all-bronze check-valves with rounded rubber facing, two gate valves with indicator posts, or rising stems and drip cocks and gauges for testing, and such physical connection is located in a vault or pit of water-tight construction readily accessible for inspection: and,

"Provided, That the application for the continuation of such a physical connection is made to the local board of health having jurisdiction and is approved by such local board of health, the date of continuance may be temporarily extended by the Department of Health of the State of New Jersey."

General Code of the State of Ohio, Section 1252-3.

"It shall be unlawful for any official, officer, or employee having in charge or being employed in the maintenance and operation of a public water supply and water-works system or for any other person, firm or corporation to establish or permit to be established any connection whereby a private, auxiliary or emergency water supply other than the regular public water supply may enter the supply or distributing system, unless such private, auxiliary or emergency water supply, and the method of connection and use of such supply shall have been approved by the State Department of Health."

Other states have made similar regulations but the above will suffice for illustration.

Action of the American Water Works Association. The fire-protection division of the American Water Works Association adopted the following resolutions at Louisville, Kentucky, May, 1925:

"WHEREAS cross-connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases, and

"WHEREAS, check-valves and other similar protective devices cannot always be depended upon, be it

"RESOLVED, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems either inside or outside of any building or buildings, and

"BE IT FURTHER RESOLVED, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections."

Action of the Conference of the State Sanitary Engineers. The following resolutions were adopted in 1926 by the Conference of State Sanitary Engineers:

"WHEREAS, cross-connections, auxiliary intakes and by-passes between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever or other water-borne disease, and

"WHEREAS, check-valves and other protective devices, or notifying the public in the case of using water from a polluted source through an auxiliary intake or by diverting the flow around an integral part of a purification plant through a by-pass, cannot be depended upon to adequately protect the public from disease,

"BE IT RESOLVED, that no physical connections should be permitted between any potable public water supplies either through cross-connections, auxiliary intakes or by-passes and other supplies except as follows:

1. With another potable public water supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems, either inside or outside of any building or buildings, and be it,

"FURTHER RESOLVED, that definite programs should be inaugurated in each state and each municipality thereof to permanently eliminate all other connections, and be it,

"FURTHER RESOLVED, that the Executive Committee of this conference transmit copies of this resolution to the Fire Underwriters Association and related organizations, also the American Water Works Association, New England Water Works Association and other analogous organizations with the request that they coöperate in securing the carrying out of the provisions of this resolution."

The full report of a special committee of the Conference is appended as Appendix C.

In its report which recommended this resolution for adoption by the Conference, the Committee defined cross-connections, auxiliary intakes and by-passes; presented a tabulation of outbreaks of typhoid fever and in some instances of enteric diseases traceable to cross-connections, auxiliary in-

takes and by-passes. This tabulation includes a total of 8 028 cases of typhoid fever with 226 deaths and also more than 11 000 cases of enteric disturbances.

Appended to the report are the results of the questionnaire summarizing the procedure for elimination of cross-connections, etc. As an example of what may be done, the experience at Chicago may be cited. A survey disclosed 428 cross-connections of which 179 were direct and 249 indirect. By the end of 1925, 85.3 per cent. of these connections had been removed.

Legal Liability. The legal cases cited in the report of the state sanitary engineers support the position that municipalities that through their officers permit cross-connections with polluted supplies become legally responsible for any epidemics resulting therefrom. In the opinion of the Committee they become legally liable if the epidemics result from any negligence in the design, installation, operation or inspection of said connections. It is also true that equal, if not greater, responsibility rests upon state authorities regarding cross-connections even though it be moral rather than legal.

Relative Hazards. In the 296 cases of interruption or failure of water supplies, recorded by the Associated Factory Mutual Fire Insurance Companies, there were 12 cases where fires occurred simultaneously.

In the 8 028 cases of typhoid and over 11 000 cases of enteric disturbance, resulting in 226 deaths, the losses by death and disability reached millions of dollars. Most of the deaths followed pollution passing through single valves or checks.

Apparently no single valve on a connection between a potable and a polluted water supply affords sufficient protection, and even the best installation of double check-valves may fail for lack of inspection.

Importance of Inspection. Where double check-valves are inspected frequently and where they are thoroughly overhauled annually, the danger due to cross-connections is greatly reduced. The permissibility of the best installation, other things being equal, therefore, hinges upon the frequency and kind of inspection.

Results of inspection of 1 032 sets of double check-valves by the Associated Factory Mutual Fire Insurance Companies showed only four cases where both valves were leaky, and in these four leakage was slight and due to lack of care. An instance has been cited*, however, where both clappers of a double check-valve installation were held partly open by a pair of overalls, thus again emphasizing the necessity for frequent inspection. (Appendix E.)

Data regarding cross-connections in New Bedford are of interest. Here the check-valves are inspected at least twice a year, and the results show both valves leaky in two out of 2 152 tests or less than one case in 1 000 inspections. Many of the installations were not of the latest type. A table summarizing the essential data relative to the tests is appended. (Appendix D.)

*Jour. N. E. W. W. A., Vol. xxvi, p. 406.

The results of the first year of periodical testing of double check-valves by the State Department of Health of Connecticut show that out of 624 tests on iron-body check-valves, there were 24 cases where one leaky valve was found and one case where both valves were found to be leaky because of unevenness in the flat, rubber seat-facings. Of 273 tests of the all-bronze valves, leaky valves (outside only) were found in 3 cases and in no case were both valves leaky. (A summary of the results of these tests is given in Appendix F.)

In view of the large number of cases of sickness and death, the neglect of even the best device is dangerous. No pains should be spared to make inspections thorough. The Committee realizes the difficulty in establishing a procedure that will prove effective for all conditions, all types of installation and all places. To indicate broad general principles rather than routine procedure seems to be the work of this committee. Nevertheless, it is believed that good results may be obtained by quarterly inspections. Furthermore, the Committee believes that, where possible, inspections should be made through the coöperative efforts of both state and municipal authorities on the one hand and the property owners and insurance companies on the other. Installations in each municipality should be examined by a state official or other competent water-works authority at least once a year.

The attention of water departments is called to the frequency of unknown and unprotected connections, not only as regards their existence but also as regards their type and condition. This relates particularly to old installations. All such connections should be sought out and, when found, should be abolished or protected.

The Committee appreciates the coöperation of the insurance companies as exemplified by the action of the Associated Factory Mutual Fire Insurance Companies who are chiefly interested in the protection of factories and mills as contrasted with general fire protection. These companies at their executive meeting on December 12, 1927, adopted the following procedure:

"a. See that every set of double check-valves, both old and new, receives the necessary supervision. Experience has shown that many risks do not appreciate the importance of keeping the double check-valves clean and tight by means of an annual overhauling. Our work would be in the line of education and assistance."

"b. Pending the decision in each case as to the final outcome, see at once that every single check-valve between potable and non-potable supplies is made accessible and kept tight as is being done in the State of Massachusetts."

"c. Make a study of fire-service connections at our plants both insured or prospective, and determine where it would be wiser to eliminate cross-connections and where best to provide other supplies. Then for those risks where cross-connections should be retained, have all-bronze double check-valves put in and provide for periodic and effective supervision of them as outlined in paragraph 'a' above."

As representing the attitude of other insurance companies the following may be quoted from a letter of George W. Booth, Chief Engineer, National Board of Fire Underwriters, published in the June 3, 1920, issue of the *Engineering News-Record:*

"The fire-protection engineer is not the responsible party in making the connection originally or in its continuance. Insurance standards require, for complete reliability, two independent sources of supply, and the plant management or the municipal authorities may, and often do, use one source which is unsafe or questionable from a sanitary standpoint, for the reason that it is a cheaper or easier one.

"The engineers of the National Board of Fire Underwriters do not, and we believe other engineers should not, favor such connections, but there are cases where they have already been made, and it is not possible, without the charge of discrimination, to refuse credit for them as emergency sources. It is, however, standard practice with many of the insurance bureaus to recommend secondary sources of supply which will be safe, as for instance, a storage reservoir.

"The double check-valve, designed some years ago for use on connections to sources of doubtful quality, has been permitted by some health authorities and has a satisfactory record. It should be installed most carefully and be maintained under a thorough inspection system."

Recent Developments in Chlorination. A method of overcoming the dangers of cross-connections between safe and unsafe water supplies suggested in the past was to sterilize secondary supplies used for fire by installing chlorinators on fire-pump suctions. Fire pumps, however, are normally idle, being merely "turned over" once a week to be sure that they are in operative condition; and once a year, during the summer, they are tested to capacity by means of hose lines attached to the yard hydrants.

A chlorinator attached to a fire pump, therefore, would normally be inoperative, and hence was not considered dependable, if called upon suddenly to operate in the emergency of a fire after having stood idle. Manually controlled chlorinators were also considered unreliable, because the operator of the pump, in the excitement of a fire, might forget to turn on the chlorine supply.

One manufacturer of water-works chlorinating apparatus has been at work on the problem, and has recently developed an automatic start-and-stop chlorinator, especially designed to be connected to fire pumps. This machine, which is of the vacuum type, utilizing liquid chlorine by reducing it to a gas, is so designed that a small auxiliary injector continually draws a small amount of chlorine gas and discharges it to waste, thus keeping the apparatus primed and assuring that it is always in operative condition. When the fire pump starts, a main injector draws the chlorine gas and discharges it in solution to the point of application on the fire-pump suction. (See Appendix H.)

There is no need of proportioning the amount of chlorine exactly to the amount of water discharged, as is necessary in water-works practice,

because the water delivered by the fire pump is not used for domestic purposes. The fire-pump chlorinator, therefore, discharges into the pump suction an amount of chlorine sufficient to care for the maximum draft from the pump, regardless of what is actually being delivered.

This chlorinator has been tested by the engineers of the New York State Department of Health. As a result of these tests, that department permits the retention of cross-connections under certain conditions, if chlorination is applied to the secondary supplies. (See Appendix G.)

Conclusions. The Committee recognizes that the only absolute safeguard for the purity of water supplies is complete separation of potable and non-potable supplies. Many cases exist in industrial as well as fire lines where cross-connections can be entirely eliminated without extensive changes or undue hazard to life and property. Such connections should be immediately abolished. In other instances the abolition of such cross-connections presents a very serious problem from the standpoint of possible loss of life and property by fire. Each case should be carefully studied on its own merits to determine the best procedure, all interests being considered. So far as possible steps should be taken in each community to provide public water supplies of sufficient adequacy and reliability, even to providing a secondary potable supply if necessary, so as to eliminate the necessity for cross-connections of any kind.

The Committee feels that pending the establishment of adequate and reliable supplies for protection of life and property from fire, experience to date indicates that double check-valves of the latest improved type, properly installed and adequately supervised, furnish the best protection of any single device now known. It is essential, however, that such installations be regularly and frequently inspected and tested. Installations of this type are relatively recent and whether or not such installations give sufficient protection, is a question that is still open for decision on the basis of further experience.

The Committee is of the opinion that the recently developed chlorinator for auxiliary supplies offers another valuable means of defence against bacteriological contamination of public water supplies through cross-connections. However, the Committee believes that more experience must be gained with this device, before it can be unqualifiedly recommended. Properly operated and maintained, the device provides a method for making polluted auxiliary supplies, bacteriologically safe, even though such supplies might continue to be non-potable.

Your Committee does not approve the use of cross-connections between safe and unsafe supplies, and wherever auxiliary supplies are made safe by treatment there should be provided the additional safeguard of proper and properly installed and inspected double check-valves. Furthermore, these valves should be used between drinking water supplies and those that while unpotable,—like pure sea water,—do not require treatment to make them safe.

The Committee strongly urges that states adopt suitable laws and regulations covering the control of cross-connections and that in each community an investigation of the existing cross-connections be made immediately and a program for the elimination or control thereof be inaugurated by the local authorities. The Committee also urges that, where possible, the inspections be made through the coöperative efforts of state and municipal authorities on the one hand and owners and insurance companies on the other. Inspections of all installations of protective devices should be made at least quarterly by an official responsible for the quality of the public water supply and such devices should be overhauled yearly.

While this report is largely concerned with cross-connections for fire service, there are many other cross-connections like those with sewers, around water-purification plants and through auxiliary intakes. None of these should be permitted.

Your Committee recommends that the following resolution be adopted by the Association:

"WHEREAS, evidence shows that the existence of certain cross-connections between safe public water supplies and unsafe private water supplies, not equipped with modern protective devices, has resulted in many outbreaks of disease and many deaths, and

"WHEREAS, such cross-connections are a hazardous part of any water-supply system.

1. This Association recommends that no cross-connection be permitted with a supply that in the opinion of the State health authorities is bacterially unsafe.

2. This Association recommends that any cross-connection permitted with a bacterially safe but non-potable supply shall be made through a properly installed and adequately supervised, all-bronze, rubber-seated, double check-valve of a type approved by the State health authorities."

Respectfully submitted,

ROBERT SPURR WESTON, *Chairman*,
JOHN S. CALDWELL,
E. SHERMAN CHASE, *Secretary*,
*STEPHEN DEM. GAGE,
*CHAS. D. HOWARD,
ARTHUR C. KING,
H. O. LACOUNT,
WARREN J. SCOTT,
STEPHEN H. TAYLOR,
ARTHUR D. WESTON.

March 14, 1928.

*Concurred in the report as a whole but dissented from the resolutions, believing that recognition should have been given to the principle that state health authorities may, at their discretion and under situations and conditions approved by them, sanction the existence of *approved* connections until such time as elimination may seem feasible.

Editor's Note: The resolution recommended by the Committee was adopted by the Association on February 13, 1929.

APPENDIX A.

EXAMPLES OF COMMON CROSS-CONNECTIONS TO POTABLE WATER SUPPLIES.

A. Cross-connections Where Secondary Supply is Available and Connected:

I. *Fire Service:*

Pipe for:

(1) Sprinklers and hydrants.
(2) Pump priming.
(3) Drinking water taken off sprinkler system or yard mains.

II. *Industrial Use:*

Pipes for:

(1) Boiler feed.
(2) Washing. Examples: paper-making processes; textile industry; tanning industry; dairying processes, etc.
(3) Cooling. Examples: condensers; mills — rubber industry; mills — pyroxylin plastic; bearings; dairying processes, etc.
(4) Quenching. Examples: coal and tar products; wire works, foundries, etc.; metal-finishing plants.
(5) Process work. Examples: dye kettles — textile and leather industries; paper manufacturing; gas manufacture, etc.

III. *Mill Use and Supply of Hotels and Office Buildings:*

Pipes for:

(1) Drinking supply — secondary supply of questionable character.
(2) Toilet supply (especially in case of direct-pressure flushing hoppers).
(3) Washing in sinks.
(4) Bathing (including swimming pools).
(5) Hydraulic elevators, lifts, presses, etc.
(6) Pressure regulation.
(7) Injectors.

IV. *Sewers (either direct or indirect through tanks).*

B. Connections to tanks, barrels, cisterns and reservoirs that are filled with chemicals or in which the water is purposely made non-potable preparatory for use in:

Paper industry.
Textile industry.
Boiler feed.
Farming or hot-houses, etc.

In these cases no secondary supply is used and no pressure exists other than a head due to height of water in receptacle. In the event of negative pressure in supply piping, the water may siphon into drinking-supply mains.

Types of Cross-connections:

(1) *Physical cross-connections* where dual supplies under pressure are permanently connected — protected usually by gate-, globe- and check-valves with various combinations.

(2) *Temporary connections* — swing joint provided where dual supplies are made available at the point of use but where little possibility exists of polluting potable supply.

(3) *Filler piece* — usually flanged — which, when removed from line, breaks cross-connection but when actually in place is same as physical cross-connection.

(4) *Open connections* — tanks that are open to atmospheric pressure may be filled from dual supplies:

(a) Where both feed pipes enter bottom and supply pipe taken from bottom — pressure on potable supply due to head of water in tank.

(b) Where polluted feed line enters the bottom — potable feed located above ordinary water level in tank.

(c) Where polluted feed line is located above ordinary water level — potable feed line enters bottom of tank — same as (a).

APPENDIX B.

PARTIAL LIST OF EPIDEMICS CAUSED BY POLLUTED WATER ENTERING DRINKING-WATER SYSTEMS THROUGH CROSS-CONNECTIONS.

The following constitutes a brief abstract of 25 instances of record in which drinking-water supplies have been polluted by entrance through cross-connections of unsafe water used for industrial purposes or for fire protection.

In 19 of these instances the cross-connection contained a single gate- or check-valve, in three instances protection against back-flow was afforded by two gate-valves or by a check-valve and a gate, and in one instance there were two gate-valves and a check-valve in series on the cross-connection. In one instance it might be assumed from the wording of the published record that protection against pollution was afforded by two gate-valves and a double check-valve arranged in series, although this was not definitely stated. In another case, however, such an arrangement was so stated.

These various instances may be classified as follows:

I. Protection by Single Gate- or Check-Valve.

A. Valve Leaked.

Albany, N. Y. Health News, New York State Dept. Health. November 21, 1927.

Epidemic of diarrhea followed by 30 cases of typhoid caused by polluted water from industrial supply leaking into city mains. There were three cross-connections, each of which was guarded by one or two gate-valves. Industrial supply pressure in excess of city pressure.

Bloomington, Ill., Jan. 1920. *Eng. News-Record*, Vol. 84, 939.

Industrial supply of Chicago and Alton Shops cross-connected with city supply. The creek from which the industrial supply was obtained went dry and a 33-in. sewer main was tapped. A leaky valve permitted this sewage to enter the municipal supply. There were 300 to 400 cases and 15 deaths from typhoid.

Philadelphia, Pa., 1920. *Eng. News-Record*, Vol. 84, p. 1 187.

Tastes and odors in the drinking water led to an investigation of the piping system at the Philadelphia Navy Yard in 1920. Several leaking single check-valves in cross-connections that were shown on piping plans of the Navy Yard were eliminated but the situation was not remedied. An unknown leaky check-valve, later found in an inaccessible place through which polluted river water, used for boiler purposes, leaked into the city system. Many cases of dysentery resulted.

Tiverton, R. I., 1926. *Bulletin*, R. I., State Board of Health, December, 1926.

Cross-connection with leaky gate between drinking-water tank and tank on fire supply in industrial plant. Fourteen cases and one death from typhoid.

Wausau, Wis. Eng. News-Record, Vol. 92, p. 348.

A factory epidemic in Wausau, Wisconsin, traced to a faulty valve in a cross-connection. Other details not given.

Winnipeg, Manitoba. Eng. News-Record, 1910, p. 677.

Polluted Red River water was used for secondary fire supply and boiler feed. A leaking valve allowed domestic service to be polluted. Twenty-five cases of typhoid.

Winona Lake, Ind., June 1925. *Pub. Health Reports*, Aug. 21, 1925.

Leaking valve on cross-connection between public supply and a polluted industrial

supply caused many cases of typhoid among Convention visitors. This cross-connection installed contrary to an order of Board of Health.

Elgin, Ill., 1916. *Jour. A. W. W. A.*, Vol. 15, No. 5, p. 477.

Leaking valve on cross-connection with a factory supply resulted in 18 deaths. Type of valve not stated.

Lawrence, Mass., 1903. JOUR. N. E. W. W. A., 1922, p. 406.

Leaking check-valve on cross-connection with mill supply caused 43 cases of typhoid.

Springfield, Ohio. 1911 Report, Ohio State Bd. of Health, p. 469.

Leaky check-valve caused 12 cases of typhoid.

Philadelphia, Pa. *Jour. A. W. W. A.*, Vol. 6, p. 750; Annual Report Bureau of Health, Philadelphia, 1913, pp. 116 and 308.

More than 300 cases of typhoid and many deaths were traced to cross-connections. An investigation showed many check-valves leaking.

Minneapolis, Minn., 1918. *Jour. A. W. W. A.*, Vol. 6, p. 773.

Leaking check-valves in cross-connections caused 18 cases and 6 deaths from typhoid.

Greystone, R. I., 1917. *Bull.* R. I. State Bd. of Health, Oct. 1917.

Forty cases of typhoid and 4 deaths probably caused by neglect to properly close gate-valves on a cross-connection between polluted industrial supply and drinking-water supply.

Milwaukee, Wis., 1912. *Jour. A. W. W. A.*, Vol. 6, p. 749.

Public supply polluted by leaking check-valves in cross-connections.

Moline, Ill. *Jour. A. W. W. A.*, Vol. 6, p. 230, 1927.

Factory supply from Mississippi River cross-connected with city supply at approximately 20 points. Investigation showed leaking check-valves probably responsible for typhoid outbreak.

B. Single Valve or Gate "Not Closed."

Rockaway, N. J., 1923. *Eng. News-Record*, Vol. 91, p. 267.

The single check-valve on a cross-connection between a fire supply and the municipal supply was "stuck open and so encrusted with dirt and rust that the flap could only be moved by the use of a bar." The fire supply was polluted by the effluent from a septic tank receiving excretions of a typhoid carrier. Temporary reduction in pressure caused fire supply to flow into town mains. Forty-one cases and 4 deaths from typhoid resulted.

Van Wert, Ohio, 1913. *Jour. A. W. W. A.*, Vol. 15, p. 477.

Sudden drop in pressure on city supply caused in flow of polluted water from polluted private supply of C. & N. R. R. Shops. Six hundred cases of sickness; 25 cases and 2 deaths from typhoid.

Everett, Wash., 1923. *Jour. A. W. W. A.*, Vol. 15, No. 5, p. 477.

Polluted industrial supply entered through open 6-in. gate. Drop in city pressure caused introduction of polluted water through open 6-in. cross-connection with an industrial supply. Two thousand cases of diarrhea; 77 cases and 11 deaths from typhoid.

Lowell, Mass., 1903. *Jour. A. W. W. A.*, Vol. 15, No. 5.

Check-valve on cross-connection between municipal and fire supply failed to close after a fire, permitting polluted water to enter city mains. Epidemic of dysentery, followed by 196 cases and 16 deaths from typhoid.

II. PROTECTION BY TWO GATES OR CHECKS IN SERIES.

Franklin Furnace, N. J. *Eng. News-Record*, Vol. 89, pp. 959 and 1 045, Vol. 91, p. 429.

An open gate-valve and a check-valve on cross-connection between municipal and industrial supplies at N. J. Zinc Co. allowed polluted water to enter town supply, causing 114 cases and 18 deaths from typhoid.

Sterling and Rock Falls, Ill., 1924–25. *Eng. News-Record*, Vol. 94, p. 526.

Polluted river water leaked by a globe-valve and a single check on cross-connection in a factory. Twelve cases and 2 deaths from typhoid.

Cohoes, N. Y. Health News, New York State Dept. Health, November 21, 1927.

Forty-seven cases of typhoid caused by pollution of city supply by Mohawk River water entering through cross-connection with industrial supply. Two gate-valves in series on connection operated once, and city pressure low five times just prior to outbreak.

III. Protection by Three or More Gates or Checks in Series.

Fort Wayne, Ind., 1923. *Eng. News-Record*, Vol. 92, p. 348.

Leakage by two gate-valves and a check-valve in series on a cross-connection at Penn. R.R. plant caused pollution of city supply. One hundred fifty cases and 22 deaths from typhoid.

Oswego, N. Y. Health News, New York State Dept. Health, November 21, 1927.

Many cases of diarrhea and 9 cases of typhoid in a factory traced to pollution of drinking water through cross-connection with industrial supply. Cross-connection protected by two globe-valves and two check-valves in series.

IV. Unclassified.

Circleville, Ohio, 1914. *Jour. A. W. W. A.*, Vol. 5, p. 447.

Polluted water from private supply leaked through two gates and two checks into city mains. Forty-three cases and 2 deaths from typhoid.

In addition to the recorded instances of troubles due to pollution entering drinking-water systems through cross-connections, carrying non-potable water for industrial or fire-fighting purposes as listed above, the Committee of the Conference of State Sanitary Engineers and other authors have listed a considerable number of instances where trouble was occasioned by the introduction of polluted water through leaks in emergency intakes or from similar causes. There is no question that the elimination or adequate protection against such chances of dangerous pollution is important and necessary. As the function of this Committee appears to be definitely limited to a consideration of direct cross-connections, references to those other sources of danger have been omitted from the tabulation.

See also Appendix C.

APPENDIX C.

REPORT OF COMMITTEE ON CROSS-CONNECTIONS CONFERENCE OF STATE SANITARY ENGINEERS.

Buffalo, June 5–7, 1926.

Resolution Recommended.

The Fire Protection Division of the American Water Works Association adopted the following resolutions at its Convention at Louisville, Ky., in May, 1925:

"*Whereas*, cross-connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases, and

"*Whereas*, check-valves and other similar protective devices cannot always be depended upon, be it

"*Resolved*, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems either inside or outside of any building or buildings, and

"*Be it further Resolved*, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections."

Your Committee believes that a similar resolution should be adopted by this Conference changing the words, however, to also include auxiliary intakes and by-passes. The following resolution is recommended for adoption:

"*Whereas*, cross-connections, auxiliary intakes and by-passes between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever or other water-borne diseases, and

"*Whereas*, check-valves and other protective devices, or notifying the public in the case of using water from a polluted source through an auxiliary intake or by diverting the flow around an integral part of a purification plant through a by-pass, cannot be depended upon to adequately protect the public from disease,

"*Be it Resolved*, that no physical connections should be permitted between any potable public water supplies either through cross-connections, auxiliary intakes or by-passes and other supplies except as follows:

1. With another potable public water supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems, either inside or outside of any building or buildings, and be it,

"*Further Resolved*, that definite programs should be inaugurated in each state and each municipality thereof to permanently eliminate all other connections, and be it

"*Further Resolved*, that the Executive Committee of this conference transmit copies of this resolution to the Fire Underwriters Association and related organizations, also

the American Water Works Association, NEW ENGLAND WATER WORKS ASSOCIATION and other analogous organizations with the request that they coöperate in securing the carrying out of the provisions of this resolution."

A report upon cross-connections by a similar committee at the meeting of the Conference in June, 1921, recommending elimination of such connections was formally adopted. In view of this report and the abundance of other data relating to the subject, your present Committee believes that only a brief, concise, final report is desirable at this time. This report, however, covers briefly the following subjects:

(1) Resolution recommended for adoption by the Conference.
(2) Definitions — cross-connections, auxiliary intakes, by-passes.
(3) Outbreaks of disease traceable to such connections.
(4) Liability of owners where disease is caused by use of polluted water.
(5) Program for elimination of cross-connections, auxiliary intakes and by-passes.

Definitions.

Cross-connections. A cross-connection is a connection whereby a potable water-supply system is connected with another water-supply system, whether public or private, in such a manner that a flow of water into the potable supply is possible therefrom, either directly through the manipulation of gate-valves or because of ineffective check- or back-pressure valves.

Examples of cross-connections include connection between the piping systems of two supplies containing either check-valves or gate-valves, or both, such as are frequently used in industries to provide auxiliary supplies for fire protection or industrial purposes. It is not intended that a cross-connection will include those permitting water from a public supply to discharge into an elevated tank, cistern or suction well, at an elevation above its high-water line or with a tank wholly supplied from the public supply and properly protected against contamination.

Auxiliary Intake. An auxiliary intake is any piping, connection or device whereby water may be secured from a source other than that normally used.

Such connections include an auxiliary intake into a river or lake where water for domestic purposes is normally secured from another source; also conditions wherein water may be pumped from another source either by the owner of the supply or other agencies into the regular distribution system.

By-passes. A by-pass is any system of piping or arrangement whereby the water may be diverted around any part or portion of a water-purification plant.

Such connections include arrangements whereby the coagulating basin filters or sterilization equipment of a water-purification plant may be by-passed.

Outbreak of Disease.

Appended is a tabulation of recorded outbreaks of typhoid fever and in some instances of a dysentery that have been caused by cross-connections, auxiliary intakes and by-passes. This tabulation includes a total of 8 028 cases of typhoid fever with 226 deaths; also more than 11 000 cases of dysentery. Other outbreaks have, undoubtedly, occurred that have not been definitely recorded or that have not been found in the search of references by your Committee. In any event the sickness and deaths are somewhat appalling and sufficient to cause any group of officials to give careful consideration to necessary steps to eliminate such dangers. The tabulation and data are presented primarily as reference for members of the Conference in presenting this question to secure the elimination of these dangerous devices.

Liability.

Courts have held on numerous occasions that the owner of a water supply, whether a municipal or a private concern, is liable for damages caused by sickness resulting from the use of a polluted water furnished by him. Below is recorded a synopsis of some such decisions:

Green v. *Ashland Water Co.* (1898) 101 Wis. 258: "If defendant knew, or from the situation ought to have known, the water it is distributing was dangerous for domestic use, from some cause not discoverable ordinarily by the exercise of reasonable care, it owed the duty to its customers of disclosing that danger, and a failure so to do, knowing that such customers were liable to use the water through ignorance of its character, was a fraud in law, rendering the defendant liable to legal damages to any person injured by such fraud without fault on his part, and it was also a failure of duty amounting to actionable negligence as well, to which the same liability is incident." Five thousand dollars verdict involved.

Lockwood v. *Dover* (1905) 73 N. H. 209: Negligence was alleged in that defendant municipal corporation failed to clean out its water pipes or to provide means whereby they could be cleaned out, and that in consequence thereof foreign and decayed matter became lodged in the city's pipes, entered the pipes leading to the plaintiff's dwelling and was there drunk by the plaintiff's intestate, causing him to sicken and die. It was held that the defendant was liable.

East Grand Forks v. *Luck* (1906) 97 Minn. 373: Based upon a study of the following cases: *Reed* v. *City of Anoka*, 85 Minn. 294, 88 N. W. 981; *Walla Walla City* v. *Walla Walla Water Co.*, 172 U. S. 1, 19 Sup. Ct. 77, 43 L. Ed. 341; *Illinois Trust & Savings Bank Co.* v. *Arkansas*, 76 Fed. 271, 22 C. C. A. 171, 34 L. R. A. 518, Judge Elliott said: "When the municipality enters the field of ordinary private business, it does not exercise governmental powers. Its purpose is not to govern the inhabitants, but to make for them and itself private benefit. As far as the nature of the powers exercised is concerned, it is immaterial whether the city owns the plant and sells the water, or contracts with a private corporation to supply the water. It is not in either case, exercising a municipal function . . . . When a municipality engages in a private enterprise for profit, it should have the same rights and be subject to the same liabilities as private corporations or individuals.

Keever v. *Mankato* (1910) 113 Minn. 55: "When a municipality voluntarily engages in selling and distributing water to customers for its local advantage or profit, it enters the field of ordinary private business, and has the same rights and is subject to the same liabilities as private corporations or individuals with respect to damages from impurity

of the water. . . . It is obvious that a sound public policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water. Nor does it appear why the citizens should be deprived of the stimulating effects of the fear of liability on the energy and care of its officials; nor why a city should be exempt from liability while a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged. Five thousand dollars awarded.

Jones v. *Mount Holly Water Co.* (1915) 87 N. J. L. 106: "Water is a necessity of life, and one who undertakes to trade in it and supply customers . . . is bound to use reasonable care to see that whatever is supplied for drink . . . shall be reasonably pure and wholesome, and that negligently furnishing water which is deleterious to that human body or health will furnish a valid cause of action to a customer injured by the use of the water." "Actual notice or knowledge of the unwholesomeness of the water of the defendant company was not an essential element to be proven in order to establish the defendant's liability; it was sufficient if there was testimony tending to show that the defendant, in the exercise of reasonable care, might have discovered the unwholesomeness and dangerous condition of the water." Seven hundred fifty dollars awarded.

Vennen v. *New Dells Lumber Co.* 154 N. W. 640: The facts in the case were briefly these; The employing company had a dual water supply in its factory; one source obtained from the city mains, the other from a nearby stream which was badly polluted. The two water distribution systems were connected by a pipe in the boiler room protected by a Globe valve reinforced by a check valve set against the polluted supply. A number of employees were in the habit of obtaining drinking water from a faucet in the boiler room which was located so that the polluted river water could reach it. Subsequent to the epidemic of 13 cases of typhoid fever and two deaths, the valves were examined and found leaky. The court held on the demurrer of the defendant that typhoid fever was a compensable accidental injury. Sued for $20 000.

It is significant that in another case — *Alex Vander Leest* v. *John Hobert Company*, Industrial Commission of Wisconsin Workmen's Compensation 10th Annual Report, July 1, 1921 to June 30, 1922, page 59, it was held by the Industrial Commission that compensation was due nineteen employees of the company who had contracted typhoid fever by use of water from a polluted well of the company. This case, however, was not carried into the courts. Compensation awarded $2 233.61, medical aid $1 742.94. Total $3 976.55.

Stubbs v. *City of Rochester* (1919) 226 N. Y. 516: One seeking to hold a city liable for injury by typhoid fever, alleged to have been contracted from defendant's polluted water system, is not bound to eliminate all other possible causes of the disease to establish defendant's liability. That a city's contaminated water supply was the source of typhoid fever in a citizen may be found from the fact that he drank water near the point of contamination, that some sixty (60) other cases developed in that vicinity, that his habits were such as to tend to exclude another probable source, while his physician testified that such contamination was the source of his illness.

Canavan v. *City of Mechanicsville*, 128 N. E. 882: A private water company or a municipality is not an insurer, nor liable as a guarantor, of the quality of the water it furnishes to its customers by the customary means of pipes and faucets, and cannot be held liable for injuries caused by impure water furnished by it, unless it knew or ought to have known of the impurity. Its duty is that of exercising reasonable and commensurate care and diligence in providing an adequate supply of wholesome water at all times.

In the case above cited the court decided that the complaint stated a valid cause of action against the defendant city on account of typhoid fever contracted by plaintiff and his children from drinking impure water.

Roscoe v. *City of Everett*, 239 Pacific 831: In discussing the case the court said: "It is sufficient to say that the evidence discloses that on April 11, 1923, a six-inch main was

laid to connect two laterals, and that when the connection was so made it permitted free circulation of water to the city users in the district served, and also better service to the Eclipse Mill Company. At the time this connection was made, there was a by-pass which had existed for a great many years. With the making of the connection there was no longer any need for the by-pass. This by-pass had in it what is known as a gate valve A — a valve worked by hand, and which when closed, effectually prevented water from passing through the pipe." . . . "There was evidence that the city never inspected the valve in the by-pass from the date of its installation." . . . "The ease with which the valve could be sealed or by-pass removed and the eminent danger to be apprehended by failure so to do are strong factors in the question of the city's negligence." Award $60 000.

Procedure for Elimination of Cross-connections, etc.

To secure data in regard to policies being followed by different State Boards of Health, questionnaires were sent out, thirty-one (31) replies being received. The questionnaire with a summarization of the answers is recorded below:

(1) Are cross-connections permitted between public water supplies and polluted factory supplies in your State? If so, under what conditions?

(a) All cross-connections prohibited	10
(b) New cross-connections prohibited	6
(c) No definite control	7
(d) Permitted with double check-valves as protection	8
	31

(2) Are auxiliary intakes whereby a polluted supply may be utilized instead of the regular public supply in case of emergency, permitted? If so, under what conditions?

(a) Auxiliary intakes prohibited	12
(b) Permitted when protected as by removing a section of the pipe	12
(c) Permitted on condition State Board of Health notified when used	5
(d) Unanswered	2
	31

(3) Are by-passes whereby any important part of a water-purification plant may be by-passed thus discharging polluted water into a public water supply, permitted? If so, under what conditions?

(a) By-passes prohibited	17
(b) Permitted with protection as by removing a section of the pipe	10
(c) No definite control	2
(d) Unanswered	2
	31

(4) What are your rules and regulations or manner of enforcement in each of the above?

(a) Definite regulations regarding cross-connections, auxiliary intakes and by-passes	6
(b) Definite regulations regarding cross-connections only	3
(c) General control as matter of policy without specific regulations	5
(d) Regulations for by-passes only	1
(e) Have power to make, but have not enacted regulations	7
(f) No regulations	9
	31

(5) What trouble have you experienced in the elimination of cross-connections, auxiliary intakes and by-passes in connection with the Underwriters Standards?

(a) No trouble	17
(b) Underwriters have objected to changes	4
(c) No definite information	10
	31

From questionnaires to states by Committees of the Conference, it is noted that in 1921 three states had regulations prohibiting all cross-connections with a public water supply and in 1926 eight states had such regulations.

There is evidently a general movement by most states toward the elimination of cross-connections. In some instances all cross-connections are prohibited, in others new cross-connections are prohibited but those existing are permitted to remain providing they are protected with double check-valves and in some states double check-valves are permitted also on new installations. One state, New York, prohibits new cross-connections and has set a definite time for the complete elimination of all cross-connections.

Your Committee believes that it is an accepted opinion that all cross-connections, auxiliary intakes and by-passes should ultimately be eliminated. The policy to be followed in bringing this about, however, depends largely upon local conditions and the procedure must be determined by the individual states. This report, therefore, does not attempt to set up a definite policy in securing the elimination of these connections but suggests the following as a possible procedure:

1. Adoption, publication and distribution of regulations by the State Department of Health —

(*a*) Prohibiting new cross-connections,

(*b*) Requiring the elimination of all existing cross-connections as soon as possible.

2. A survey of all cross-connections with public water supplies directly by the State Department of Health if possible or otherwise a survey by each municipality with definite reports back to the Department.

3. A definite follow-up program by correspondence and inspections to see that the regulations of the Department are carried out.

Typhoid Epidemics Caused by Cross-connections, Auxiliary Intakes and By-passes.

A. Cross-connections.

Place.	Year.	Typhoid.		Intestinal Disturbances.	References and Remarks.
		Cases.	D'ths.		
Amsterdam, N. Y.	1920	22	1	....	Reports on File.
Auburn, N. Y.	1908	58	..	....	J. N. E. W. W. A. Vol. 24, p. 407.
Binghamton, N. Y.	1923	13	..	....	Report on File.
Bloomington, Ill.	1920	130	15	400	J. A. W. W. A. Vol. 7, p. 560.
Bluff Point, N. Y.	1916	15	?	....	Health News, N. Y. St. Dept. Health, Oct. 1920.
Circleville, Ohio	1914	43	3	?	Ohio St. Bd. Health Rpt. 1914, pp. 724–730.
Eau Claire, Wis.	....	13	2	....	154 N. W. 640.
Elgin, Ill.	1916	Many	18	?	J. A. M. A. 1917, Vol. 68, p. 465.
Everett, Wash.	1923	77	?	2 000	U. S. P. H. S. Rpts. 1924. Vol. 39, No. 13, pp. 605–611.
Fort Wayne, Ind.	1923	150	22	?	E. N.-R. Vol. 92, p. 348, 1924.
Franklin, N. J.	1922	114	18	?	E. N.-R. Vol. 89, pp. 959–1 045, 1922; Vol. 91, pp. 429–1923.
Hartford, Conn.	1918	?	?	?	E. N.-R. Vol. 87, No. 10, 1921, pp. 409–11.
Hyde Park, Mass.	1907	Several	?	?	J. N. E. W. W. A. 1922, p. 406.
Lawrence, Mass.	1903	43	?	?	J. N. E. W. W. A. Vol. 22, p. 235.
Lowell, Mass.	1903	172	9	Thousands	J. A. M. A., 41; 151–5, 1903. Proc. A. M. W. A. 1913, p. 153; E. N.-R. 51; 125.
Mannington, W. Va.	1916	Several	?	?	J. A. W. W. A. Vol. 6, p. 752.
Maywood, Ill.	1920	0	0	75	Bull. Ill. Dept. Health, Cir. No. 7; Nation's Health, June, 1926; E. N.-R. 86, 310, 1921.
Mechanicsville, N. Y.	1920	15	?	?	Report on File.
Massachusetts	Three instances				J. A. W. W. A. Vol. 6, p. 753.
Milwaukee, Wis.	1912	?	?	?	J. A. W. W. A. Vol. 6, p. 749; Kee W. W. An. Rpt. 1912, p. 21.
Minneapolis, Minn.	1918	18	6	?	J. A. W. W. A. Vol. 6, p. 773.
Nashua, N. H.	....	?	?	Many	J. N. E. W. W. A. Vol. 24, p. 382.
Newburgh, N. Y.	1918	5	?	Many	An. Rpt. N. Y. St. Dept. Health, 1920.
Niagara Falls, N. Y.	1925	1	0	0	U. S. P. H. Rpt. Aug. 1925.
New Bedford, Mass.	1903	?	?	?	J. N. E. W. W. A. Vol. 17, 1903, p. 69.
Newport, Vt.	1924	16	4	?	Letter from St. Dept. Health.
Nitro, W. Va.	....	...	..	....	J. A. W. W. A. Vol. 6, p. 752.
Philadelphia, Pa.	1913	309	?	?	Engr. News, N. 20, 1913, pp. 1 022–3.
Philadelphia Navy Yard	1920	?	?	Several	E. N.-R. Vol. 84, No. 25, 1920, p. 1 187.
Piedmont, W. Va.	....	470	?	?	J. A. W. W. A. Vol. 6, p. 753.
Rochester, N. Y.	1910	58	?	?	J. A. W. W. A. 1920, Vol. 7, p. 648.

TYPHOID EPIDEMICS CAUSED BY CROSS-CONNECTIONS, AUXILIARY INTAKES AND BY-PASSES.

A. Cross-connections (Continued).

Place.	Year.	Typhoid.		Intestinal Disturbances.	References and Remarks.
		Cases.	D'ths.		
Rockaway, N. J.	1923	41	4	?	Engr. News, Vol. 91, 1923, p. 267.
Rockford, Ill.	1924–25	12	2	?	E. N.-R. Vol. 94, 1925, pp. 525–27.
Seneca Falls, N. Y.	1920	102	?	?	Report on File.
Sheboygan, Wis.	1925	11	0	Several	Rpt. St. Bd. Health, 1925.
Springfield, Ohio	1911	12	?	?	An. Rpt. Ohio St. Bd. Health, 1911, p. 469.
Sterling & Rock Falls, Ill.	1924	12	2	?	Ill. Dept. Public Health, Cir. No. 7, Nation's Health, June, 1925.
St. Paul, Minn.	1914	?	?	80	J. A. W. W. A. Vol. 6,p.752.
State of Illinois	5 outb	reaks 80	0 ?	?	Letter from H. Ferguson, Oct. 15, 1923.
Toronto, Ont.	....	5	?	?	Proc. A. W. W. A. 1913, p. 163.
Utica, N. Y.	1917	49	?	Many	An. Rpt. N. Y. St. Dept. Health, 1917.
Van Wert, Ohio	1913	33	5	600	Rpt. Ohio St. Bd. Health, 1916.
Winnipeg, Manitoba	1908	26	3	....	E. N.-R. 17: 507, 1910.
Wolfpit, Ky.	1925	67	7	?	Letter from Ky. St. Bd. Health, Apr. 3, 1926.
Woonasquatucket, R. I.	1917	40	4	?	Qr. Bul. St. Dept. Health, Vol. 3, No. 4, 1917, pp. 26–30.

TYPHOID EPIDEMICS CAUSED BY CROSS-CONNECTIONS, AUXILIARY INTAKES AND BY-PASSES.

B. Auxiliary Intakes and By-passes.

Place.	Year.	Typhoid.		Intestinal Disturbances.	References and Remarks.
		Cases.	D'ths.		
Herkimer, N. Y.	1918	155	28	?	Health News, N. Y. St. Dept. 1920.
Moine, Ill.	1918	125	24	?	Data by Mr. Ferguson, Ill.
Milwaukee, Wis.	1916	4 500	40	5 000–6 000	St. Bd. Health Rpt. 1916.
Neenah, Wis.	1920	19	8	Few	St. Bd. Health Rpt. 1918–1920.
Schenectady, N. Y.	1900	53	3	?	.....
Tonawanda, N. Y.	1919	236	?	?	J. A. W. W. A. Vol. 7, pp. 176–8, Mar. 20; Can. Engr. 38; 439, May 6, 1920.
Charleston, Ill.	1925	0	0	3 000	Data by Mr. Ferguson, Ill. (By-pass existed, epidemic by inadequate filtration and failure to chlorinate.)

Note by N. E. W. W. A. Committee:
The possibility of error in the above Table should be noted. In the case of Auburn, N.Y., and Nashua, N. H., the Table is known to be in error and some doubt exists as to accuracy in certain other instances.

APPENDIX D.

RECORD OF CHECK-VALVE TESTS AT NEW BEDFORD, MASS.

Summary January, 1927.

Number of Plants having check-valves on city connections	54
Total number of sets of double checks in service, Jan. 1, 1927....	81

Classification as to make:

Chapman	52 Sets
Fairbanks	12 „
Pratt-Cady	7 „
G.F.E.	6 „
Ludlow	4 „
Total	81 „

Classification as to size:

6-in.	28 Sets
8 „	41 „
10 „	12 „
Total	81 „

Date Installed:	No. of Sets.	Years in Service.	Valve Years.
1910	3	16	48
1911	4	15	60
1912	13	14	182
1913	20	13	260
1914	4	12	48
1915	23	11	253
1916	4	10	40
1917	4	9	36
1920	2	6	12
1921	2	5	10
1925	1	1	1
1926	1	..	..
Total	81		950

Period of Service:

Minimum	0 Yrs.
Average	11.7 „
Maximum	16.0 „

Total Number of Tests:

Total	2 152
Per set	26.5
Per set per yr. in use	2.26

Results of Tests:

Both leaking (one in 1 000)	2
One leaking (one in 94)	229
Both tight (one in 1.12)	1 921
Total	2 152

Openings for Examination:

Total	436
Per set	5.4
Per set per yr. use	.46
Once every	2.2 yr.

Classification of Causes of Leakage:

Corrosion	8 Times
Tuberculation	127 „
Not seating	50 „
Gasket poor	36 „
Obstructions	3 „
Unstated	8 „
	232 „

NOTE: — Leak caused by mechanical defect 50/232 = 22% of times
Leak caused by tuberculation 55% of times

Repairs:

New facings total	178
New facings for each valve	178/81 × 2 = 1.1 for 11.7 yrs.
Once in every	10.6 yrs.
New clappers (soon after installation of old type Pratt-Cady)	9
New clapper arms	22
Repaired clapper arms	40 times in total time.

APPENDIX E.

RESULTS OF LATEST TESTS BY INSPECTION DEPARTMENT ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES OF SPECIAL TYPE F. M. DOUBLE CHECK-VALVES IN FACTORY MUTUAL RISKS.

	Both Tight.	Outside Leaky.	Inside Leaky.	Both Leaky.	Not Tested.	Total Number.
Canada	114	15	2	1*	3	135
Maine	27	2	2	0	1	32
New Hampshire	27	2	0	0	5	34
Vermont	4	1	0	0	0	5
Massachusetts	238	20	3	0	8	269
Rhode Island	16	4	0	0	0	20
Connecticut	114	2	1	0	7	124
New York	120	25	9	1†	4	159
New Jersey	52	8	2	1‡	2	65
Pennsylvania	27	3	1	0	5	36
Delaware	1	1	0	0	0	2
Maryland	2	1	0	0	0	3
Virginia	9	2	0	0	0	11
West Virginia	1	0	0	0	0	1
Ohio	17	1	1	0	3	22
Kentucky	1	0	0	0	0	1
Indiana	11	0	3	0	0	14
Michigan	7	3	0	0	1	11
Minnesota	1	0	0	0	0	1
Wisconsin	14	0	0	1§	0	15
Illinois	10	0	0	0	5	15
Iowa	1	0	0	0	0	1
Missouri	2	0	2	0	0	4
North Carolina	5	5	1	0	0	11
South Carolina	3	1	0	0	0	4
Georgia	0	2	2	0	2	6
Tennessee	2	0	0	0	1	3
Alabama	4	0	2	0	1	7
Louisiana	0	0	1	0	0	1
Total Sets						1 032

*Secondary supply from cistern. New rubber facings appear to be necessary. Mill promised immediate attention.
†Cleaning had been neglected. Cleaned at once by mill mechanics who reported both left tight.
‡Cause unknown. Being corrected by mill.
§Cleaning had been neglected. Being corrected by mill.

When a valve is classed as leaky it does not mean that water was passing back through the valve, but that, if the pressure on the downstream side of the clapper were raised above that on the other side, water might pass through that particular valve but not through the set as a whole.

Valves listed as not tested are practically all new installations that have not as yet been provided with testing facilities.

May 2, 1927.

APPENDIX F.

RESULTS OF TESTS OF DOUBLE CHECK-VALVES BY CONNECTICUT STATE DEPARTMENT OF HEALTH DURING 1927.

Iron-body Valves.

Number of tests	624
Outside check only leaking	17
Inside check only leaking	7
Both checks leaking	1*
Both checks O.K.	599
Tests O.K. on second try	4†

All-bronze Valves.

Number of tests	273
Outside check only leaking	3
Inside check only leaking	0
Both checks leaking	0
Both checks O.K.	270
Tests O.K. on second try	0

*This leaking installation was inspected by the manufacturers of the check-valves, who found the cause to be unevenness in the flat rubber facings.

†Counted O.K. because of the likelihood that any flow through the pipe would flush out sediment noted under quiescent conditions. These might be considered as leaking in one valve.

APPENDUM TO APPENDIX F.

RESULTS OF TESTS OF DOUBLE CHECK-VALVES BY CONNECTICUT STATE DEPARTMENT OF HEALTH FOR YEAR — JULY 1, 1927–JUNE 30, 1928.

Iron-body Valves.

Number of tests	668
Outside check only leaking	18
Inside check only leaking	6
Both checks leaking	4*
Both checks O.K.	640

All-bronze Valves.

Number of tests	291
Outside check only leaking	1
Inside check only leaking	0
Both checks leaking	0
Both checks O.K.	290

*These were confined to two installations and steps were taken to remedy the conditions.

APPENDIX G.

DEPARTMENT OF HEALTH, ALBANY

July 3, 1928.

Chlorination of Auxiliary Water Supplies. Referring to our circular letter of June 29, 1928, regarding the chlorination of auxiliary fire supplies, a special fire-pump chlorinator has been developed which we find, as the result of tests, is capable of effectively chlorinating an auxiliary supply under intermittent operation of fire pumps and rendering such auxiliary supply potable provided it is not too grossly polluted.

This chlorinator is designed to operate continuously and constantly discharge to waste a small amount of chlorine solution and to automatically apply a predetermined amount of chlorine to the suction of the pump the instant the pumps start, thereby overcoming the limitations of intermittent chlorination. If, therefore, the conditions at an industrial plant are such as to make it exceedingly difficult, or impracticable, to completely sever the cross-connections between a potable public water supply and a polluted auxiliary supply, it is our opinion that the installation and proper maintenance of such a chlorinator will, by making the auxiliary supply potable from the standpoint of public health, satisfactorily meet the requirements of Regulations 15-a and 15-b of Chapter VII of the Sanitary Code and protect the public water supply of a municipality. Such installations must, however, meet the following requirements:

1. The water supply must not be so grossly polluted that it cannot be effectively chlorinated.
2. The fire pump must either take suction from an open well or sump or there must be a municipal water supply available having a pressure at least three times as great as the pressure on the suction of the pump.
3. The water supplying the ejectors of the chlorinator must be from the municipal supply.
4. The chlorination equipment must be of a type approved by this Department and so equipped as to continuously waste a small amount of chlorine solution and provided with solenoid or steam operated valves so regulated that immediately upon the starting of the pump it will apply chlorine at a rate of not less than twenty pounds of chlorine per million gal. of water pumped.
5. Platform scales must be provided for checking the loss of weight of chlorine.
6. Plans of the installation, together with report and sufficient data to pass upon it, must be submitted for approval to both the local water authorities and to the State Department of Health.
7. Reports of the results of daily ortho-tolidin tests of the chlorine solution wasted and the amount of chlorine wasted or used per day must be submitted at least monthly to the municipal water-supply authorities.
8. Chlorinators on all auxiliary industrial or fire supplies must be inspected regularly and at frequent intervals by local water-supply authorities.
9. The cross-connection between a potable municipal supply and a

chlorinated auxiliary industrial or fire supply must be equipped with double check-valves of the "all bronze" type placed in an accessible chamber and properly equipped for testing and inspection. Such check-valves must be inspected and tested at least monthly and taken apart, thoroughly cleaned and any worn parts replaced at least yearly.

10. Discharge valves on the fire pumps must be closed whenever the pumps are turned over for testing.

11. Any approval by the municipal and water-supply authorities or this Department will be given only on condition that the chlorination apparatus is satisfactorily installed, operated and maintained at all times.

Every effort should be made by the public water-supply authorities or owners to require either the elimination of all cross-connections between their supplies and non-potable auxiliary supplies or the effective chlorination of such auxiliary supplies as soon as possible and not later than January 1, 1929. Those in charge of public water supplies should have ordinances or regulations based upon Sections 15-a and 15-b of Chapter VII of the Sanitary Code and not inconsistent therewith enacted without delay, requiring the elimination of cross-connections or the chlorination of auxiliary supplies, if such action has not already been taken. The existence of a cross-connection between a potable public water supply and a non-potable auxiliary industrial or fire supply after January 1, 1929 will be illegal.

M. NICOLL, JR.,
State Commissioner of Health.

APPENDIX H.

AUTOMATIC START-AND-STOP CHLORINATOR FOR FIRE PUMPS.

The accompanying sketch shows in diagrammatic form the principle of operation of the automatic start-and-stop chlorinator attached to a fire pump.

A. Chlorine cylinders each containing either 100 or 150 lb. of liquid chlorine at a pressure of approximately 100 lb. per sq. in.

B. Chlorine inlet-valve operated by a hard-rubber float resting on the surface of the water under the glass bell jar. The hard-rubber float opens valve "B" when the vacuum under the bell jar produced by the injectors "D" or "F" lifts the water level inside.

C. Outlet for a continuous small flow of water and chlorine gas which is drawn out by auxiliary injector "D" and discharged to waste.

D. An auxiliary injector, operated from the city-water pressure using about 500 gallons of water per day and discharging to waste approximately 1 to 3 lb. of chlorine per day. This slight continuous flow keeps valve "B" in operation and the apparatus primed, hence assuring that it is always operative.

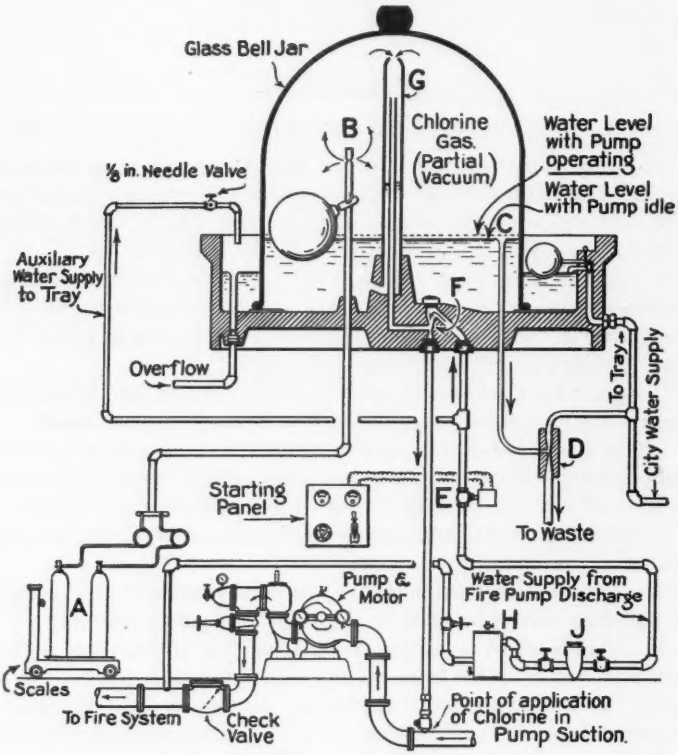
The normal water level in the tray and under the bell jar is maintained by a ball-float valve connected to the same city-water supply line.

E. A valve which is automatically opened by the starting of the fire pump, and admits water from the fire pump discharge pipe to the main injector "F". For an electrically-driven fire pump, "E" is a solenoid-operated water-valve wired in parallel with the fire pump motor through the starting panel. For a steam pump, "E" is either a steam- or hydraulically-operated water-valve. For rotary pumps, "E" will be either hydraulically- or mechanically-operated water-valve. To insure that the tray and bell jar are supplied with water should the city water fail while the fire pump is operating, an emergency water supply to the tray is taken from the supply to the main injector just above valve "E" which is supplied by a connection from the fire pump discharge.

F. The main water injector which draws chlorine gas through orifice-meter "G" and discharges the chlorine in solution to the point of application in the fire-pump suction.

G. A glass orifice-meter which delivers a fixed rate of gas flow to main injector "F". The draft of injector "F" increases the vacuum inside of the meter tube "G", thus raising the water level in this tube to a calibrated mark and indicating the correct rate of flow of chlorine gas.

H. A sand trap made up of a 36-in. length of 8-in. pipe capped at both ends and installed in the water supply to the main injector "F". This water supply is taken in practically all cases from the fire-pump discharge on the yard side of the check-valve as shown on sketch. A sand trap is necessary only when the water contains settleable grit.



AUTOMATIC CHLORINATOR FOR FIRE PUMPS.
Diagrammatic Sketch Showing
Principle of Operation.
(Not to scale.)

I. Two one-inch strainers installed in parallel in the water supply from fire-pump discharge to main injector "F". One strainer is kept shut off and held for use when the other is being cleaned.

When the fire pump is running and main injector "F" is in operation, the increased vacuum inside of the bell jar raises the water level to the upper position, as indicated by the dotted line. This raised water level covers outlet "C" and cuts off the discharge of waste chlorine gas and then supplies auxiliary injector "D" merely with water. The raised water level also tends to keep valve "B" open, thus supplying the chlorine for main injector "F".

When the fire pump is shut down and main injector "F" is no longer operating, the water level will fall to the top of injector suction-tube "C" as indicated by the solid line whereupon auxiliary injector "D" will draw off both water and the small amount of chlorine gas which feeds past inlet-valve "B".

INDEX OF ADVERTISERS.

	Page
Ambursen Construction Co.	ii
Badger Meter Mfg. Co.	xv
Barbour, Frank A.	ii
Barrows, H. K.	ii
Biggs Boiler Works Co.	xliv
Bingham & Taylor	v
Boston Pipe & Fittings Co.	xxvii
Buffalo Meter Co.	x
Builders Iron Foundry	ix
Byers, A. M., Co.	xxvi
Caldwell, Geo. A., Co.	xxxiv
Cement Lined Pipe Co.	xxvii
Central Foundry Co.	xlii
Chadwick-Boston Lead Co.	xxxix
Chapman Valve M'f'g Co.	xxxii
Clark. H. W., Co.	xxiv
Conard & Buxby	ii
Copper & Brass Research Association	xlv
Dixon, Jos., Crucible Co.	xix
Donaldson Iron Co.	xxxiv
Eddy Valve Co.	xxxiii
Edson Manufacturing Co.	xxxvii
Fairbanks-Morse & Co.	xxi
Fay, Spofford & Thorndike	ii
Ferullo, G., Co.	iii
Ford Meter Box Co.	xlvi
Fox, John & Co.	xxxvi
Fuller & McClintock	ii
Gamon Meter Co.	xiii
General Pipe Cleaning Co.	iii
Golden-Anderson Valve Specialty Co.	xliii
Hayes Pump and Machinery Co.	xix
Hays M'f'g Co.	xli
Hazen, Everett & Pirnie	ii
Hersey M'f'g Co.	iv
Houdlette, Fred A., & Son	xxvii
Hydraulic Development Co.	xl
Kennedy Valve Mfg. Co.	xxix
LaMotte Chemical Products Co.	xlvii
Lead Lined Iron Pipe Co.	xxxvi
Leadite Co.	xxxviii
Lock Joint Pipe Co.	Facing front cover
Ludlow Valve M'f'g Co.	xxxi
Main, Charles T. Inc.	ii
Main, M. B.	xxv
Mazsur, F. A. & Co.	xvii
McWane Cast Iron Pipe Company	xxv
Merrimac Chemical Co.	xxiv
Metcalf & Eddy	ii
Michigan Pipe Co.	Back cover
Mueller Co.	xvi
Murray Iron Works Co.	xx
National Meter Co.	xiv
National Water Main Cleaning Co.	xxx
Neptune Meter Co.	vi
Paradon Mfg. Co.	lii
Pierce-Perry Co.	xxvii
Pitometer Company	iii
Pittsburgh Equitable Meter Co.	vii
Power Equipment Co.	xix
Rensselaer Valve Co.	xxxi
Ross Valve M'f'g Co.	xxx
Simplex Valve & Meter Co.	xii
Smith, The A. P., M'f'g Co.	xxiv
Starkweather & Broadhurst	xviii
Sumner & Dunbar	xxvii
Symonds, Henry A.	iii
Thorpe, Lewis D.	iii
Turbine Equipment Co.	xxii
Union Water Meter Co.	xi
U. S. Cast Iron Pipe and Foundry Co.	xxxv
Wallace & Tiernan	xxiii
Ware Coupling and Nipple Co.	xxv
Warren Foundry and Pipe Co.	xxxvii
Weston & Sampson	ii
Wood, R. D., & Co.	xxviii
Worthington Pump and Machinery Corp.	viii

(Classified index on page xlviii)

ENGINEERS' SECTION

FULLER & McCLINTOCK
Engineers

NEW YORK, 170 Broadway

Philadelphia, Pa., Pennsylvania Bldg. 15th and Chestnut Streets
Kansas City, Mo., Walsix Bldg. 600 Walnut Street

H. K. BARROWS
M. Am. Soc. C. E.
Consulting Hydraulic Engineer

Water Power, Water Supply, Sewerage, Drainage. Investigation Reports, Valuations, Designs, Supervision of Construction

BOSTON, MASS. 6 BEACON ST.

CONARD & BUZBY

Assoc. Mem. Amer. Soc. C. E. Assoc. Amer. Soc. M. E.

322 High St., Burlington, N. J.

Inspections and Tests of Materials

Reports Specifications
Designs Inspections
Tests

WESTON & SAMPSON
Consulting Engineers

Robert Spurr Weston George A. Sampson

Water Supply and Sewerage
Chemical and Bacteriological Laboratory

14 BEACON ST. - BOSTON, MASS.

FAY, SPOFFORD & THORNDIKE
Consulting Engineers

Investigations Reports Designs
Engineering Supervision Valuations

Port Developments Industrial Plants
Bridges Buildings Foundations

Water and Sewerage Works

44 SCHOOL STREET BOSTON

HAZEN, EVERETT & PIRNIE
Civil Engineers

ALLEN HAZEN C. M. EVERETT
MALCOLM PIRNIE L. N. BABBITT

WATER WORKS
Design Construction Operation
Valuations Rates

25 West 43rd Street = New York City

METCALF & EDDY
ENGINEERS

Harrison P. Eddy
Charles W. Sherman
Almon L. Fales
Frank A. Marston
John P. Wentworth
Harrison P. Eddy, Jr.
Arthur L. Shaw
E. Sherman Chase

Water, Sewage, Drainage, Refuse and Industrial Wastes Problems
Laboratory

STATLER BUILDING BOSTON

FRANK A. BARBOUR
Consulting Engineer

Water Supply, Water Purification, Sewerage and Sewage Disposal.

Tremont Building, Boston, Mass.

CHAS. T. MAIN, INC.
ENGINEERS
201 DEVONSHIRE STREET
BOSTON, MASS.

Plans and Specifications for Textile and other Industrial Plants, Water Power and Steam Power Developments. Examinations and Reports on Plants with reference to their Value, Reorganization or Development.

AMBURSEN DAMS
Hydroelectric Developments
Water Supply and Irrigation Dams
DAMS ON DIFFICULT FOUNDATIONS
AMBURSEN CONSTRUCTION CO.
Incorporated
Room 2520, Grand Central Terminal Bldg., New York
Kansas City, Mo. Atlanta, Ga.

HENRY A. SYMONDS
Consulting Engineer
70 State St., Boston, Mass.
WATER SUPPLY
Surveys — Estimates — Designs
Supervision
MANAGEMENT AND ORGANIZATION
EFFICIENCY REPORTS

LEWIS D. THORPE
Civil and Sanitary Engineer
Water Works, Sewerage and Sewage Disposal
Supervision of Construction and Operation
6 Beacon Street
BOSTON, MASS.

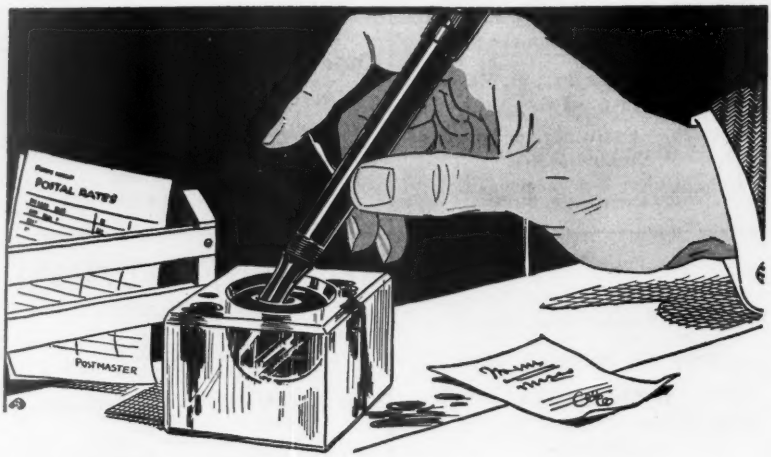
Your Professional card
may be inserted here
at $12 per year

THE PITOMETER COMPANY
ENGINEERS
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
50 Church Street New York City

Clean Corroded Pipe and Water Mains.
Clean pipe lines deliver more water and give better fire protection at less cost than do corroded mains.
Let us help you with your problems.
GENERAL PIPE CLEANING COMPANY
735 Commercial Trust Bldg. Philadelphia, Pa.

CONTRACTORS

G. FERULLO COMPANY
General Contractors
Specializing in Water Works
31 NORTH SQUARE
BOSTON, MASS.
Telephone, Richmond 1200



POST-OFFICE INK

STREET hawkers sell fountain pens by telling customers that the pens can be filled free at the Post Office. They can't sell the pens on merit so they resort to a low price and an offer of free ink.

When the sole advantage of a Water Meter is its low price — look out. It's not what a meter costs, but what it ***does*** that counts.

Quality performance is the basis on which Hersey Water Meters are sold.

On small flows of water Hersey soon gives you your money back. Hersey Water Meters register all flows down to 1/32 of an inch. Leaks from ball-cocks, flush bowls, and dripping faucets can't escape the sensitive Hersey Disc Piston. The Disc Piston of Hersey Water Meters is kinetically balanced. There's no friction to impede the ease of its nutation. That also means less wear and more service.

Invest in Hersey Water Meters. Quality always pays in the long run.

The Hersey Disc Meter is completely dipped-tinned, the best known protection against corrosion.

Hersey Manufacturing Company, South Boston, Mass.

HERSEY
WATER METERS

NEW YORK, N. Y. ..... 290 Broadway
PORTLAND, ORE. ..... 475 Hoyt St.
PHILADELPHIA, PA. ..... 314 Commercial Trust Bldg.
ATLANTA, GA. ..... 610 Citizens and Southern Bank Bldg.
DALLAS, TEX. ..... 2301 Griffin St.
CHICAGO, ILL. ..... 10 So. LaSalle St.
SAN FRANCISCO, CAL. ..... 690 Market St.
LOS ANGELES, CAL. ..... 450 East Third St.

Main Office and Works: Corner E and 2nd Sts., South Boston, Mass.

WE wish to take this opportunity to thank the New England water companies and their managers for the valued orders they gave us during 1928.

Due to an increase of 30% in sales, we have been able to make a price reduction on cast iron

Service Boxes
Valve Boxes
Roadway Boxes
Meter Boxes

} **All Large Units**

Write for our new catalogue and discount sheet.

Bingham and Taylor Corporation

575-601 Howard Street . . Buffalo, N. Y.

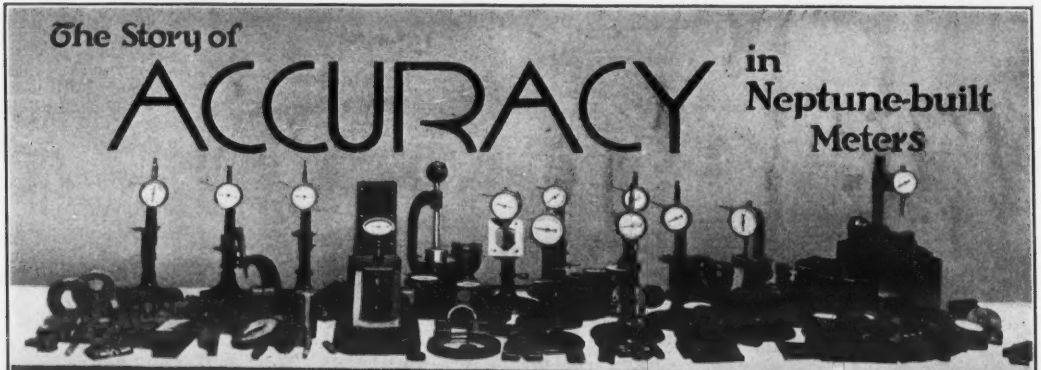
These Check Gear-Trains and Registers

The Trident Gear-train alone is gauged some 75 times during production of its parts and all interchangeable parts are again 100% inspected before assembling. And every detail, from the finest wheel on the Register is gauged and inspected in the same manner. The gauges shown here are used in this step of Neptune production.

NEPTUNE METER CO.
THOMSON METER CORP.
50 EAST 42nd ST.
NEW YORK CITY

"Pioneers in Meter Progress"
Yesterday, TODAY, Tomorrow

The Story of
ACCURACY
in Neptune-built Meters



To Insure Sustained Accuracy

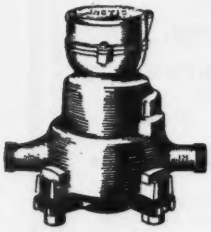
in Neptune-built meters, we make these meters for hard service, rugged, durable — yet with the fine care and high standards of exactness that go into the production of a high-grade watch. No wonder then that of Trident and Lambert Meters more than 5,000,000 have been made and sold the world over — and the sales-curve still rises!

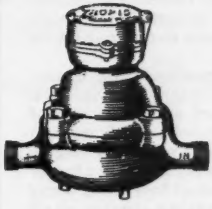
TRIDENT METERS

LAMBERT METERS

Sandblasted-

EVERY precaution is taken to assure our users high grade perfect castings. In addition to the tumbling barrel method of cleaning, every casting used in the manufacture of Pittsburgh Equitable Meter Company water meters, is cleaned by the sand blasting and acid bath process. Clean castings are essential to the efficient water meter.

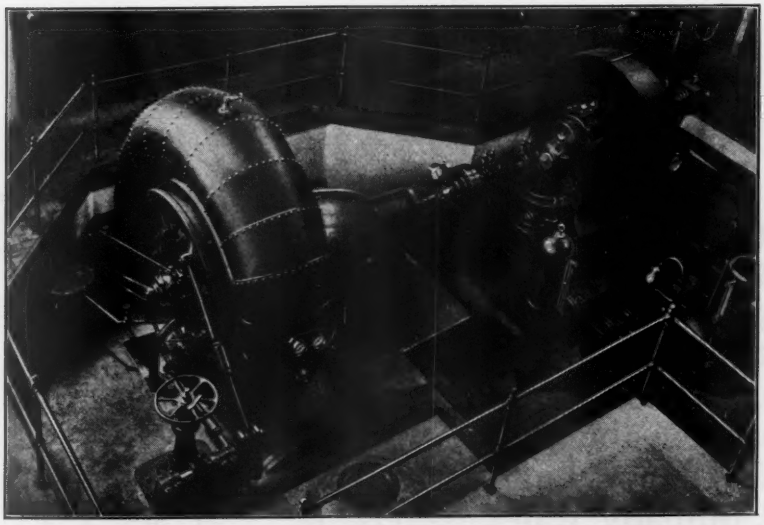

ARCTIC


TROPIC

Pittsburgh Equitable Meter Co.

Pittsburgh, Pa.

Branch Offices:	Kansas City, Mo.	New York, N. Y.	Dallas, Tex.
	Tulsa, Okla.	Chicago, Ill.	Los Angeles, Cal.
	Seattle, Wash.	Columbia, S. C.	Salt Lake City, Utah



Worthington 14 in. x 12 in. Vertical, Triplex. Single-acting Pump driven by 135-hp. turbine water wheel. Capacity 1,750,000 gal. in 24 hr. against 132-lb. per in. discharge pressure. Pumping Station, Willimantic, Conn. Henry W. Taylor, Consulting Engineer.

Worthington Unit *solves vexing problem*

THE City of Willimantic found that its pumping costs were mounting. During the dry, summer months the steam-driven pumps, standby for water wheels, were being used to an increasing extent. Investigation showed that better designed machinery was required if pumping costs were to compare with those of other cities.

A Worthington Triplex, Single-acting Pump, direct-connected to an S. Morgan Smith water wheel has been installed. The pump is furnished with two sets of plungers and throats, one set to deliver 1.5 million g.p.d. and the other 1.75 million g.p.d. Any one of the three smaller plungers may be replaced by a larger to allow a gradual accommodation to increased water consumption. This without changing driving shaft speeds to cause reduced water-wheel efficiency.

One year of continuous operation has proved the adequacy of the design and its complete accommodation to the operating conditions of the unit.

Henry W. Taylor, Consulting Engineer, says:

"New and properly designed machinery has solved an economic problem which was developing an item of considerable expense.

"The new pumping unit takes up a relatively small floor area and has been arranged to fit the space available in an old building where trying conditions had to be met."

WORTHINGTON

PRODUCTS

PUMPS

COMPRESSORS

CONDENSERS
and Auxiliaries

OIL *and* GAS ENGINES

FEEDWATER HEATERS

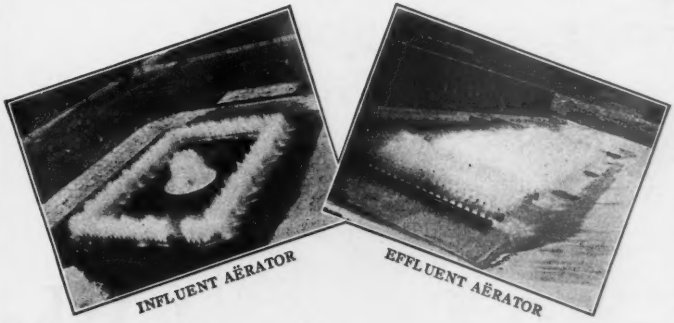
WATER *and* OIL METERS

Literature on Request

WORTHINGTON PUMP & MACHINERY CORPORATION
2 PARK AVE., NEW YORK CITY - BRANCH OFFICES IN 24 CITIES

WORTHINGTON

39-6241-S



Views at new Providence Water Works Scituate, R. I.

At Providence

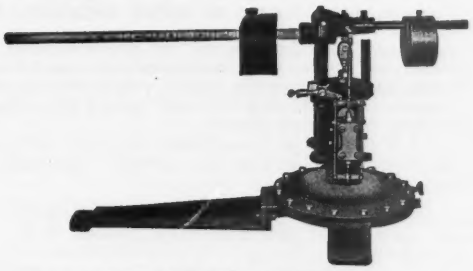
Hazen & Whipple Consulting Engineers, New York, N. Y.

the expenditure of twenty million of dollars and eight years of construction have resulted in providing the city of Providence with an abundant supply of pure clear water.

The Filter Effluent Aërators, a novel idea devised by the Consulting Engineers and developed by Builders Iron Foundry, is of particular interest. The head of water on the filter is used to produce secondary aëration. Constant flow through the filters is maintained by special Venturi-controlled mushroom valves which open gradually as the loss of head increases.

Special Venturi Meters measure the total water entering and leaving the plant; Builders Loss of Head and Rate of Flow Gages guide the operation of the filters.

Write for descriptive bulletins.



CONTROLLER PILOT VALVE UNIT

BUILDERS IRON FOUNDRY

"Builders of the Venturi for 36 Years"

Providence VENTURI "VENTURI" Registered **Rhode Island**

When the Horseless Carriage was the Terror of the Roads, the BUFFALO METER COMPANY was eight years old.

'Way back in 1900, when automobiles were becoming common, more than fifteen thousand Niagara and American water meters were in service in approximately two hundred municipalities in the United States.

Today nearly a million are in use. Every civilized country in the world has municipalities or industries in which Niagara or American water meters are giving continuous, trouble-free service.

Many of the first Niagara and American water meters, installed years before the horseless carriage was the terror of the roads, have been operating steadily without attention of any kind. There is every indication that these meters will continue to serve for many more years to come.

You owe it to your municipality to get the facts on these long life Niagara and American water meters. Just mail the convenient coupon below.

BUFFALO METER COMPANY
2896 Main Street, Buffalo, N. Y.

NIAGARA (IRON CASE) *and* AMERICAN (BRONZE CASE) Water Meters

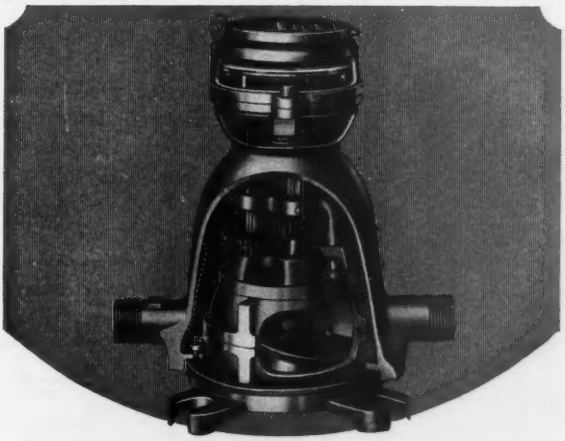
BUFFALO METER COMPANY,
2896 Main Street, Buffalo, New York.

Gentlemen: Without cost or obligation on my part, please send your 1929 catalog illustrating and describing Niagara and American water meters.

Name..... Title.....

City..... State.....

Announcing Our
Sixtieth Anniversary Meter



King F. P.

King F. P. (frost protected) Meter is built to overcome every known weakness in frost meter design. Among the new features built into the King F. P., which users of meters will immediately recognize as marked advances, are the position of the thrust roller, an eccentric which locks the disc chamber in place, and the use of monel metal pins and lock screws which yield to excessive pressure such as frost.

The thrust roller is located on the outlet side of the disc slot, and is held in place by a monel metal pin which balances the weight perfectly and strengthens this edge of the disc, always heretofore the weakest point. Friction thrust is reduced to a minimum because the roller keeps the control in the center. The roller is made of hard rubber and this perfect insulation eliminates corrosion and galvanic action.

The new method of holding the disc chamber in place employs an eccentric which simplifies installation or removal of the chamber, and eliminates any possibility of the chamber becoming bound. The intermediate gearing is assembled by the use of three slideable monel metal pins held in place on the side by a single lock screw. The same intermediate gearing is used on all sizes of meters and therefore is interchangeable. All bearings are oversize, insulated, adjustable and renewable.

It is with much satisfaction that Union Water Meter Company announces the perfection of the King F. P. Meter on the sixtieth anniversary of the incorporation of this company.

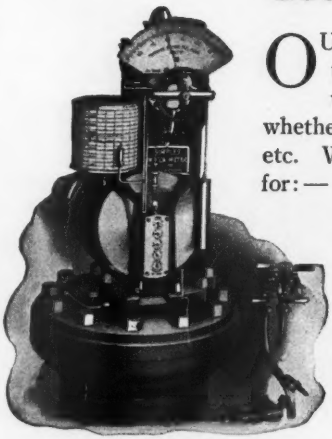
UNION WATER METER COMPANY

Incorporated 1868

WORCESTER, MASS.

New York: 50 Church St. **Philadelphia: 411 Bulletin Bldg.**

Is Your Pressure Low?
Are You Short on Pumping Capacity?
Do You Know Where Your Water Goes?



OUR Engineering Department will tell you how to determine your water distribution, how to find out whether or not new mains are required, etc. We can supply you with the means for:—

1. Checking up pump performance and determining slippage due to leaky plungers, defective valves, short stroking or other causes,
2. Measuring delivery of centrifugal pumps and figuring whether or not the station is up to efficiency,
3. Distributing proportionately the cost of water supplied to several districts,
4. Checking up the performance of filter beds,
5. Detecting waste or pipe leakage,
6. Recording daily amounts of sewage handled and planning future extensions, etc., etc.

THE SIMPLEX METER

VENTURI, PITOT TUBE OR ORIFICE TYPES

THE importance of exact measurements by means of a Simplex Meter cannot be over emphasized. Mr. Jeffries, Chairman of the West Chester, Pa. Water Works Committee, was able, by checking the performance of his pumping engine with a Simplex Meter, to discover that due to the imperfection and wear in the valves the slippage amounted to 300,000 gallons of water per day. This represented a daily loss of $30.00, or in other words a daily saving of $30.00, or $900.00 per month, when the valves were put in order. The Simplex Meter thus paid for itself in a month's time.

Frequent repeat orders from satisfied customers who formerly used other meters are the best evidence of merit of the Simplex Meter.

We have had many years' experience in solving water flow problems involving all sorts of conditions, and we are at all times prepared to submit general layouts involving cost and capacity, and to make explicit and complete recommendations. Write for Bulletin N26.

SIMPLEX VALVE AND METER COMPANY

Manufacturers of Meters for Water, Sewage, and Other Liquids, Rate Controllers, Automatic Air Valves, Regulating Valves, and Hydraulic Apparatus of Special Design.

6757 UPLAND STREET PHILADELPHIA, PA.

"WATCH DOG" WATER METERS

ACCURATE *DURABLE*

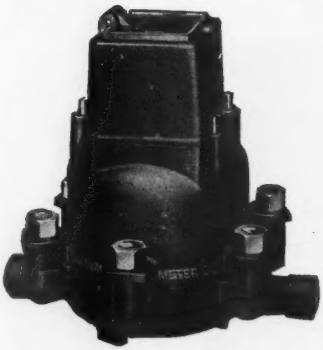
DISC, CURRENT AND COMPOUND TYPES

Inquiries Solicited

GAMON METER COMPANY

NEWARK **NEW JERSEY**

METERS



The NASH

(DISC TYPE)

There are many reasons why the NASH is the best meter for your work. For instance:

It is an all bronze meter, closely accurate, and built for long wear.

The intermediate is enclosed and is unsurpassed by any other on the market.

The design of the ports takes up the water thrust, and does away with the thrust-roller.

The NASH has the simplest, best and most economical frost feature of all — a breakable flange washer that gives full protection and costs almost nothing to replace.

In fact, any good point or modern improvement to be expected in any disc meter, you will find in the NASH.

Let us send you a sample meter, so you can see for yourself. A postal request does it.

NATIONAL METER COMPANY

299 Broadway, New York

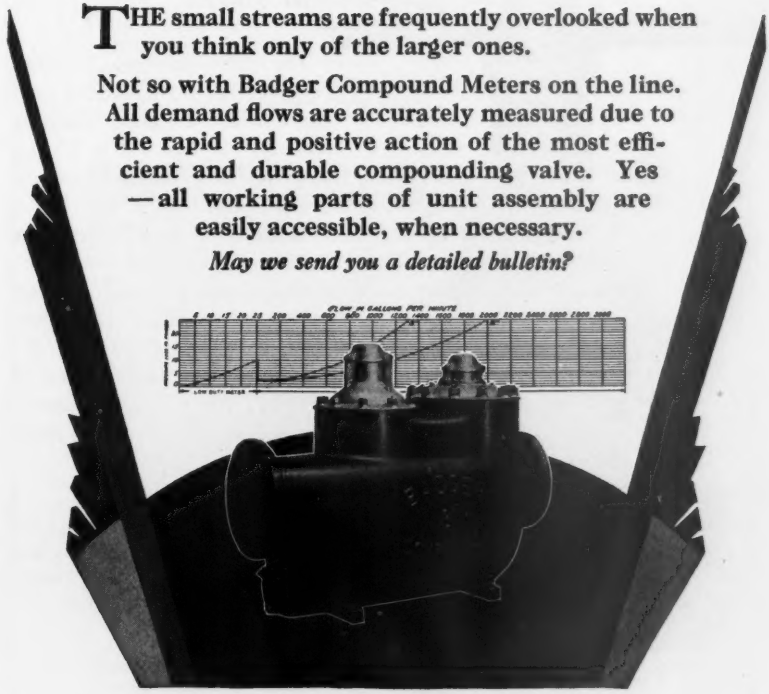
Chicago Boston Cincinnati Atlanta
San Antonio San Francisco Los Angeles

ARE YOU COLLECTING A JUST RETURN FROM LARGE CONSUMERS

THE small streams are frequently overlooked when you think only of the larger ones.

Not so with Badger Compound Meters on the line. All demand flows are accurately measured due to the rapid and positive action of the most efficient and durable compounding valve. Yes —all working parts of unit assembly are easily accessible, when necessary.

May we send you a detailed bulletin?



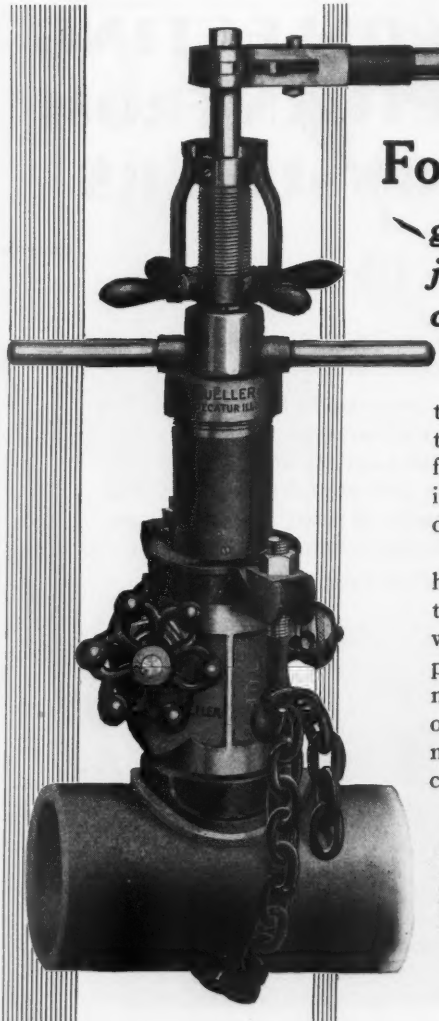
BADGER METER MANUFACTURING COMPANY

MILWAUKEE WISCONSIN

Branch Offices:

NEW YORK CITY LOS ANGELES, CAL. CINCINNATI, OHIO
KANSAS CITY, MO. CHICAGO, ILL. SEATTLE, WASH.

BADGER Water METERS



For real results

give the man on the job a machine he can work!

For three-quarters of a century waterworks men have used the Mueller Tapping Machine for making taps ½″ to 1″ and inserting corporation stops under pressure.

Because in all this time one has never failed on the job — today, ninety per cent of waterworks men have indicated their preference for the Mueller "B" machine. This machine has all of the latest improvements, making it easy to do a quick, clean job.

MUELLER CO. (*Established 1857*), Decatur, Illinois. *Branches:* New York, Dallas, San Francisco, Los Angeles. *Canadian Factory:* MUELLER, Limited, Sarnia.

MUELLER

Send for a complete description of the "B" Tapping Machine and list of parts.

ATTENTION
WATER WORKS
OF NEW ENGLAND

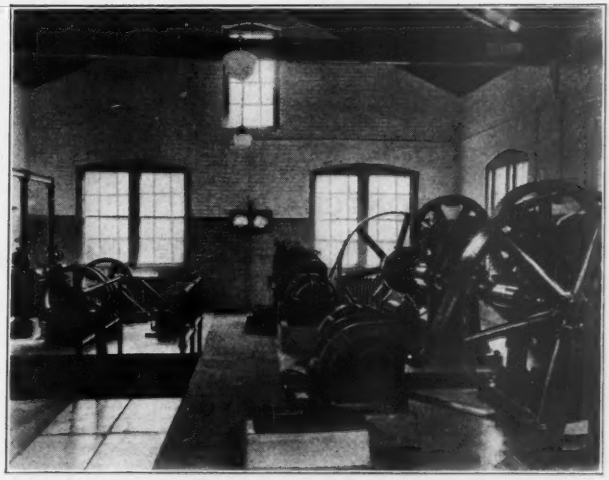
A few reasons why we solicit your inquiries on Water-Works Pumping Equipment:

First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

Third. — We relieve the purchaser of every detail and turn the complete unit over to him under actual operation and with guarantee.

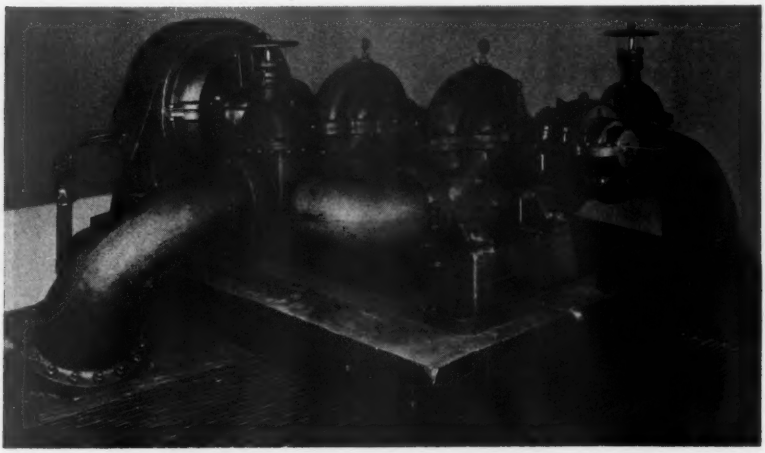
Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.



Remodeled Pumping Station at Bridgewater, Mass., completely installed by F. A. Mazzur Co., Inc. Barbour & Dixon, Eng'r's.

F. A. Mazzur Co., Inc.

141 MILK STREET, BOSTON



HIGH SERVICE UNIT

AT

WATCHUNG AVENUE STATION

MONTCLAIR, N. J.

ARTHUR P. HEYER, Commissioner of Public Works

METCALF & EDDY

ENGINEERS, BOSTON

CAPACITY, 4 M.G.D. AGAINST 350′ TOTAL HEAD

MOTOR, 325 to 350 H.P. AT 1775 to 1785 R.P.M.

COMBINED EFFICIENCY, 75 to 80%

WM. G. STARKWEATHER, M.E. JOHN B. STARKWEATHER, B.S.

STARKWEATHER & BROADHURST, INC.

CONTRACTORS, BOSTON

79 MILK STREET HANcock 4530

HAYES PUMP AND MACHINERY CO.

94 PEARL ST., BOSTON, MASS.

Pumping Plant Contractors

CENTRIFUGAL, POWER, STEAM PUMPS

STEAM TURBINES
WATER WHEELS

ELECTRIC MOTORS
OIL ENGINES

Standpipes
Water Tanks
Gas Holders
and all other metal surfaces need the protection of
DIXON'S
Silica-Graphite
PAINT
BOOKLET NO. 87-B
JOSEPH DIXON CRUCIBLE CO. Jersey City, N. J.

WE announce our appointment as Sales Representatives of DAYTON-DOWD COMPANY, of Quincy, Ill., Manufacturers of Centrifugal Pumping Machinery. After exhaustive investigation, we present this line of equipment to the Trade in New England as being of the highest grade and thoroughly modern in design and manufacture.

We are prepared to furnish DAYTON-DOWD pumps in all sizes and for all classes of service, in steam, motor, gasoline and belt drive types, and solicit your inquiries, assuring you of our best efforts in your sales and service requirements, and of our appreciation of your continued confidence and patronage.

POWER EQUIPMENT CO.

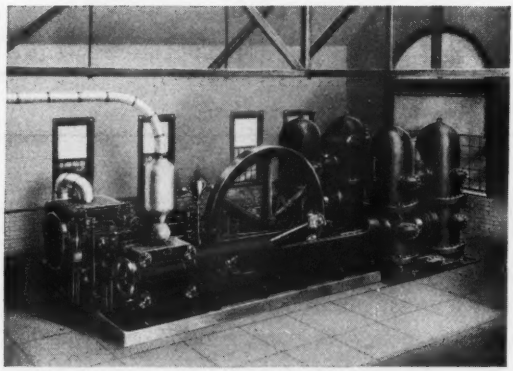
131 State Street, **Boston, Mass.**

MURRAY IRON WORKS CO.

(INCORPORATED 1870)

BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines

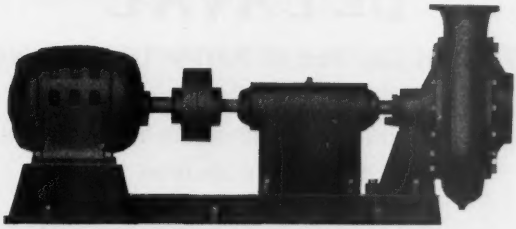


Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

STARKWEATHER & BROADHURST, INC.,
79 MILK STREET, BOSTON

will be glad to show you the superior design and excellent workmanship of the new 3 M. G. D. Murray Pump in the Arlington Pumping Station of the Metropolitan District Commission. Exceptional operating results are being obtained as shown by the official duty test which exceeded the guaranty by a substantial amount.

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS



Fairbanks-Morse Horizontal Trash Pump direct-connected to Fairbanks-Morse Ball-Bearing Motor

Now a great advance in sewage pumping

For the first time a pump has been designed that will handle fluids containing the fibrous and stringy matter found in sewage — without clogging, without preliminary screening, and without the excessive power consumption that characterizes the less satisfactory open impeller type of pump.

The secret of this pump's success lies in the design of the simple two-blade impeller. The blades of the impeller have well-rounded entering ends and are well filleted with the shrouds or sides. Thus a rag or other trash does not find sharp projections on which to catch and cause clogging. Since the impeller is the enclosed type, foreign matter, in passing through, does not come into contact with stationary side plates, but is promptly discharged through one of the large ports into the pump case. In this way power is conserved and efficiency increased.

This pump was designed by Mr. A. B. Wood who has been serving the city of New Orleans and other municipalities in the capacity of consulting engineer. It was originated by Mr. Wood to cope with the very unusual sewage problems found in New Orleans and met with immediate success.

Fairbanks-Morse Trash Pumps are made in two types, horizontal and vertical. They are ruggedly built to cope with severe service and at the same time they possess such refinements as ball bearings, smoothed fluid passages, and other marks of quality construction.

Ask for bulletins giving complete details.

FAIRBANKS, MORSE & CO., Chicago

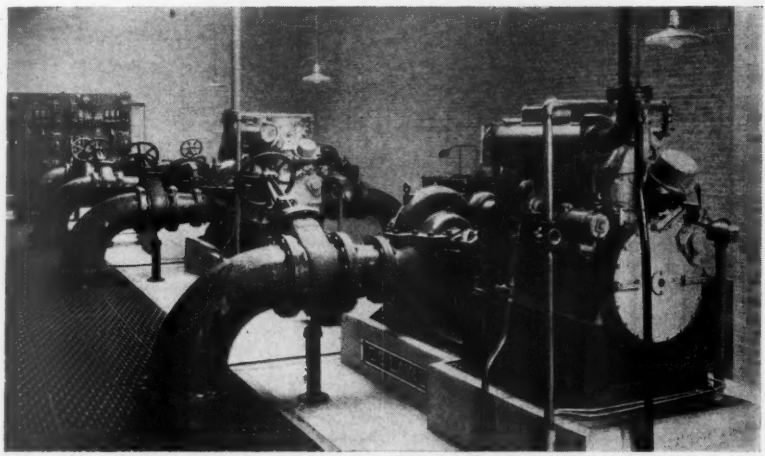
28 branches in principal cities at your service.

FAIRBANKS-MORSE

PUMPS · DIESEL ENGINES · MOTORS

DE LAVAL

Steam Turbines and Pumps, Marine Turbines and Gears
Worm Gear Reductions
Oil Purifiers, Clarifiers, Dehydrators
Reclaiming Systems



Bath Street Station, Providence, R. I.

New pumping station equipped with two De Laval automatic motor driven and two De Laval gasoline engine driven emergency pumping units each designed to deliver 2 000 gallons per minute of water against 98 feet total head. Contract included furnishing and erection of pumps, motors, gasoline engines, switchboard, gages, tanks and piping.

TURBINE EQUIPMENT CO. of NEW ENGLAND
ENGINEERS AND CONTRACTORS
80 Federal St., Boston **Telephone, Liberty 5998**

New England Representative for
DE LAVAL STEAM TURBINE COMPANY
Trenton, N. J.

The floods are coming!—

PHOTO BY NASHVILLE AERONAUTIC CORP.

THE CUMBERLAND RIVER IN FLOOD, NASHVILLE, TENN.

—Will you be ready?

THIS spring—as in all other springs—the floods will come. Rivers will overflow.—Surface water supplies will be excessively polluted.—Ground water levels will rise.—Well waters will become contaminated!

Will you be ready?

Will you have a spare W&T chlorinator—and a supply of Liquid Chlorine on hand to render emergency service? Will you be ready to chlorinate that polluted water and avoid the sure toll of pestilential disease?

Water sterilization—always important—is absolutely vital in times of flood.

But why wait for the flood?

Continuous chlorination costs but one cent per head per year and absolutely prevents water-borne disease.

There is no cheaper public health insurance.

"The only safe water is a sterilized Water"

WALLACE & TIERNAN

COMPANY, INCORPORATED

Manufacturers of Chlorine Control Apparatus

NEWARK, NEW JERSEY

NEW YORK CHICAGO KNOXVILLE SAN FRANCISCO MINNEAPOLIS PITTSBURGH DALLAS KANSAS CITY LOS ANGELES SEATTLE ST. LOUIS BUFFALO HARRISBURGH INDIANAPOLIS DETROIT WALLACE & TIERNAN, LTD., TORONTO, CANADA WALLACE & TIERNAN, LTD., LONDON, ENGLAND

H1

CMC

FILTER ALUM

FOR NEW ENGLAND WATER WORKS

MERRIMAC CHEMICAL COMPANY

148 STATE ST. BOSTON

MANUFACTURERS OF FILTER ALUM
SINCE 1886

Four-Point Superiority in Smith Standard Valves.

SMITH Standard Valves have at least four points of superiority: Simplicity, Non-Corrosion, Operation in Any Position, Manganese Bronze Stems.

Send for Valve Booklet

SMITH — WATER WORKS SPECIALTIES & SUPPLIES — A.P.S. 1928

THE A.P. SMITH MFG. CO. *East Orange, N.J.*

The ORIGINAL METER BOX

was built by Clark — 36 years ago — and today the most scientifically designed and carefully manufactured Meter Box is built by Clark.

Clark Meter Boxes are built to meet every condition of climate, soil or traffic — no meter has ever frozen when properly installed in a Clark Meter Box. The "Perfect" and "Wonder" locking lids with which Clark Meter Boxes are equipped, are strong, quick acting and tamper proof.

Send your specifications for water distributing equipment to

CLARK

Meter Boxes — Service Boxes
Meter Couplings — Meter Testers

Valve Boxes and Housings
Trouble Finding Instruments

H. W. CLARK COMPANY
Manufacturers of Water Works Necessities
Mattoon, Ill., U. S. A.

CAST IRON PIPE

PRECALKED JOINT PIPE

Bell and Spigot—Sand Cast—Modern Weights

Sizes: 1¼ through 12 inches. Lengths to 16 feet

Boston stocks. Furnished with or without Precalked Joints

McWane Cast Iron Pipe Company

Eastern Office: 123 South Broad Street Philadelphia

Sales Representatives:
FRED A. HOUDLETTE & SON
40 Central Street, Boston
Eastern Mass., Me., N. H.

General Offices: BIRMINGHAM, ALA.
Foundries: BIRMINGHAM, ALA., PROVO, UTAH

Main's Hotcoating for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

Also

Main's Coverall Salt Air Paint, for the outside of standpipes and water tanks, guaranteed for four years.

M. B. MAIN **Box 189, Somers Point, N. J.**

GRIP PIPE FITTINGS

Connect without threading

As an Emergency Pipe Clamp

Before

After

Makes Possible an Immediate Repair. Saves Both Time and Money

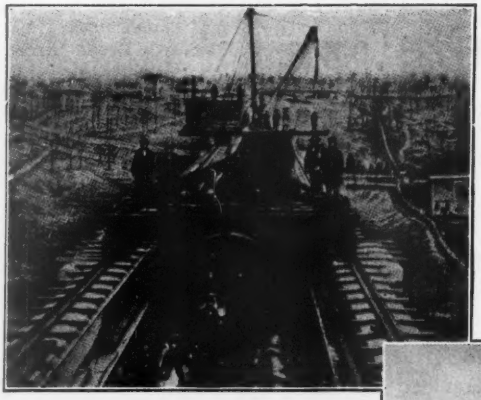
MANUFACTURED BY

WARE COUPLING & NIPPLE CO.

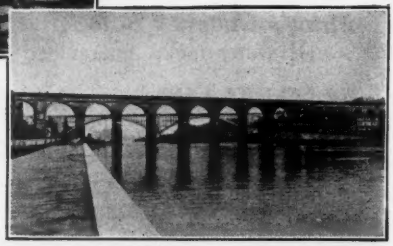
WARE, MASS., U. S. A.

Four Generations Have Passed

since the Croton Aqueduct was built . . . .



Yet the wrought iron pipe is still good for generations more!



Away back in the 60's, before the Civil War, a 90-inch wrought iron pipe was installed on High Bridge to carry water from the Croton Aqueduct, across the Harlem River, to New York.

In 1925, when plans for altering High Bridge were being discussed, the question arose whether the big water main was in a condition to be worth saving.

"Good for twenty years," reported the engineers after careful inspection. "Capable of being made to last another sixty years if a protective coating is applied to the inside."

Not a unique but a noteworthy example of the sterling qualities of genuine wrought iron pipe, in water works economy.

Genuine wrought iron is the material from which Byers Pipe has always been made. All the virtues for which Byers Pipe has been known to four generations are built into every length turned out by the Byers mills. The bright Spiral Stripe, which is the Byers mark, is an assurance of lasting service.

A. M. BYERS COMPANY
Established 1864
PITTSBURGH, PA.
Distributors in all Jobbing Centers

the *Spiral Stripe*
protects you against mistakes and substitution
Also look for name and year rolled in metal

BYERS PIPE

GENUINE WROUGHT IRON

PIERCE-PERRY CO.

SUCCESSORS TO
GEORGE E. GILCHRIST CO.

JOBBERS OF
Heating and Plumbing Supplies
Steel, Wrought Iron and Brass Pipe
Water Works Materials

DISTRIBUTORS OF
Hoffman Valves and Controlled Heat Equipment

236 Congress Street, Boston.

BOSTON PIPE & FITTINGS CO.

WHOLESALE JOBBERS

Byers Genuine Wrought Iron Pipe

National Pipe

COMPLETE LINE OF WATER WORKS SUPPLIES

273-279 CONGRESS ST., BOSTON

NOTICE:

Water-Works Contractors and Supply Houses!

Your card may be inserted here at a rate of $12 per year.

We Carry in BOSTON STOCK for Immediate Shipment

CAST IRON BELL AND SPIGOT WATER PIPE AND FITTINGS
FLANGED PIPE in full and short lengths
WROUGHT PIPE

FRED A. HOUDLETTE & SON
(Incorporated)

40 Central Street, Boston, Mass.

Quotations furnished promptly for shipment from Foundry

CEMENT LINED SERVICE PIPE

With Specially Adapted Lead-lined Fittings

Also Curb Cocks which eliminate Iron to Brass Corrosion both inside and out.

CEMENT LINED PIPE CO.
LYNN, MASS.

SUMNER & DUNBAR

Manufacturers of and Dealers in
S. & G. Water Works Brass Goods
Byers' Wrought Iron Pipe
Service and Valve Boxes
Cast Iron Pipe and Fittings

12-18 Pittsburgh Street - - Boston, Mass.

Telephone, Liberty 1350

MATHEWS

(Reg. U.S. Pat. Off.)

FIRE HYDRANTS

For Standard and High Pressure Service

Mathews Hydrants are simple in construction; hence durable, easily repaired, and maintained at low cost.

A real Frost Case makes Mathews Hydrants completely frost proof, and with an easily installed

Extension Section

makes the Mathews readily adaptable to new grades and conditions.

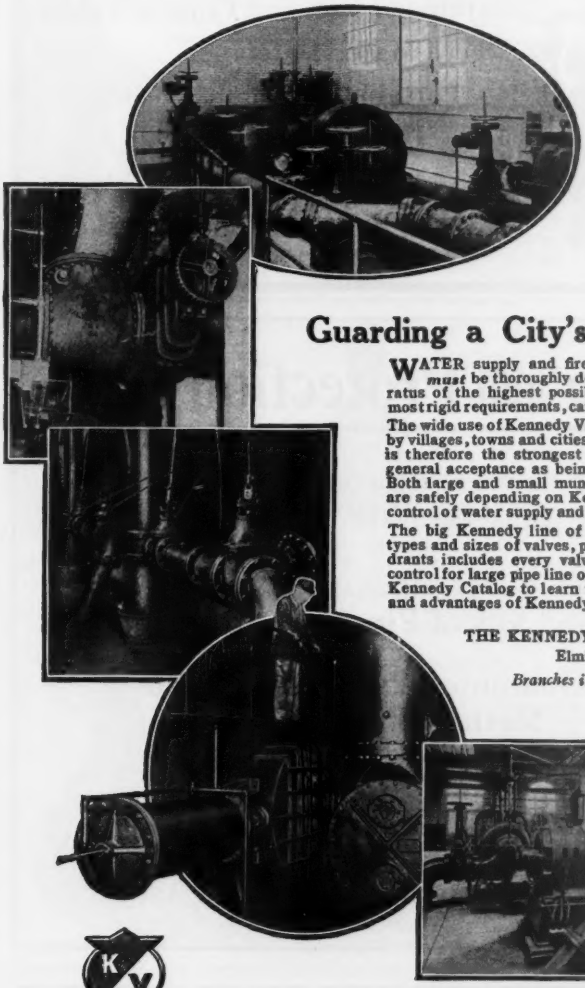
Water Works Gate Valves
Valve Boxes—Indicator Posts

CAST IRON PIPE FITTINGS

"Sand-Spun" centrifugally cast pipe
Cast in refractory molds
No chill—Standard bell and beaded spigot

R. D. WOOD & CO.

PHILADELPHIA, PA.



Guarding a City's Welfare

WATER supply and fire protection equipment *must* be thoroughly dependable. Only apparatus of the highest possible grade, meeting the most rigid requirements, can be used.

The wide use of Kennedy Valves and Fire Hydrants by villages, towns and cities throughout the country is therefore the strongest possible proof of their general acceptance as being reliable and efficient. Both large and small municipalities by the score are safely depending on Kennedy products for the control of water supply and fire protection systems.

The big Kennedy line of thousands of different types and sizes of valves, pipe fittings and fire hydrants includes every valve size and method of control for large pipe line operation. Send for the Kennedy Catalog to learn the distinctive features and advantages of Kennedy products.

THE KENNEDY VALVE MFG. CO.
Elmira, N. Y.
Branches in principal cities

KENNEDY

VALVES~PIPE FITTINGS~FIRE HYDRANTS

Automatic Pressure Control Valves
Feed Water Filters
Portable Fire Hydrant Heads
Hydraulic Engines
Hydraulic Booster Pumps

ROSS VALVE MFG. CO., INC. **TROY, N. Y.**
ESTABLISHED 1879

Health and Protection First

Water delivered through dirty pipes may be a MENACE.

Incrusted water pipes mean inefficiency and loss of Fire Protection.

We Guarantee the Results of Our Method of Cleaning.

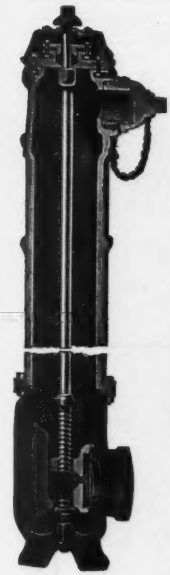
WRITE US.

National Water Main Cleaning Co.

50 Church Street **New York City**

A Classified Directory

of Advertisements is arranged for your convenience in the back of this Journal.



LUDLOW VALVE MFG. CO.

MANUFACTURERS OF

VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.

DOUBLE AND SINGLE GATE **VALVES,**
ALSO CHECK **VALVES,**
FOOT **VALVES.**

FIRE **HYDRANTS.**

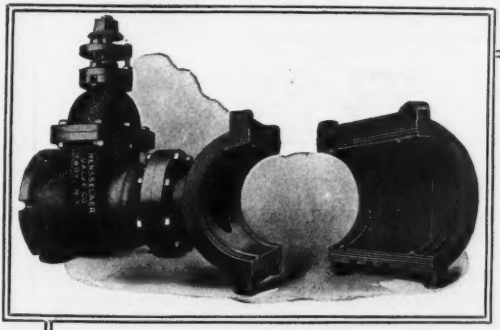
YARD, WASH, AND FLUSH **HYDRANTS.**

☞ SEND FOR CIRCULARS ☜

OFFICE AND WORKS: FOOT OF ADAMS STREET, TROY, N. Y.

BRANCH OFFICES:

NEW YORK	PHILADELPHIA	BOSTON	PITTSBURGH	CHICAGO	KANSAS CITY
62 GOLD ST.	HARRISON BLDG.	1112 TREMONT BLDG.	1ST NAT. BANK BLDG.	THE ROOKERY	R. A. LONG BLDG.



Rensselaer Tapping Sleeves

were brought out to meet a growing demand for a "BETTER" Tapping Sleeve. They were designed to suit conditions met in actual practice.

They can be used with all standard makes of Tapping Machines.

POINTS OF
SUPERIORITY

Have two lead rings.

Require less lead for calking.

Iron washers not required.

Bolting flanges are made full length of sleeve, giving great strength.

Have greater thickness of hubs on ends.

Easier to center on pipe before pouring lead.

Cost less to install.

Book No. 11 gives full information.

Ask for prices.

CHARLES L. BROWN
New England Sales Manager, Lock Box 2, Northboro, Mass.

RENSSELAER VALVE COMPANY, TROY, N.Y.

THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

Gate Fire Hydrants

Corporation Cocks Curb Cocks

Anderson Couplings

Lead Pipe Connections

Trade

Mark

WRITE FOR OUR WATER-WORKS CATALOG

Main Office and Works
Indian Orchard, Mass.

BRANCH HOUSES

BOSTON, MASS. 141 High St.
NEW YORK CITY 180 Lafayette St.
PHILADELPHIA 1011 Filbert St.
CHICAGO 116 N. Jefferson St.

Type of Eddy Hydrant Popularly Used

More Than Sixty Years of Experience Goes Into All

EDDY

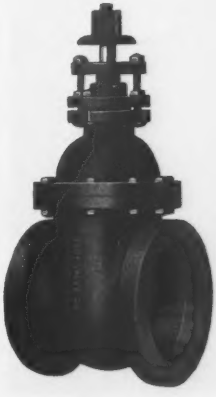
Hydrants and Valves

BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

The Eddy Valve, Too



Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.

Other Eddy Products

The Eddy line of water-works products also includes horizontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

WRITE FOR CATALOGUE

EDDY VALVE COMPANY

WATERFORD, N. Y., U. S. A.

EMAUS PIPE FOUNDRY,
DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND...

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

J. G. EBERLEIN, President and Treasurer.
J. M. GILBERT, Secretary.

EMAUS,
LEHIGH COUNTY, PA.

CALDWELL "LEAKFINDR"

Listening for leak at hydrant

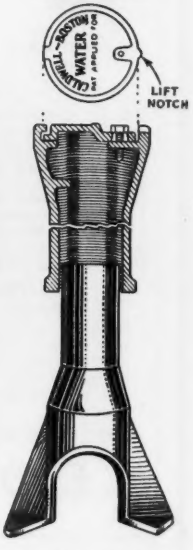
Locating leak in the ground

Pronounced by Leading Water Works Superintendents the Best Instrument for the purpose on the market.

Manufactured and Sold by

GEO. A. CALDWELL CO. - - MATTAPAN, MASS.

No. 1 CALDWELL CURB BOX

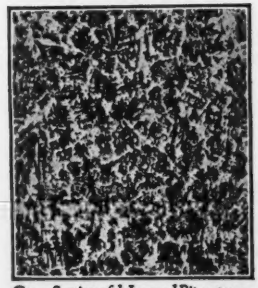


deLavaud is 25% stronger

than any other CAST IRON PIPE

and . . . here's the reason why

Sand Cast Pipe. Micrograph showing center of wall cross-section. Magnification 100 times. Note the long flakes of brittle graphite.



Cross-Section of deLavaud Pipe at center of wall. Magnification 100 times. Observe the even grain and the finely divided condition of the graphite.

IT HAS long been known by chemists and engineers that the finer and less angular the graphite particles of any cast iron, the stronger will be the metal itself.

A direct comparison of the micrographs shown here will explain very clearly why deLavaud is mechanically superior to any other cast iron pipe.

The upper illustration shows a cross-section of a piece of ordinary cast iron pipe magnified 100 times. Upon close examination we find that the continuity of the mass is broken up by extremely long flakes of coarse graphite.

Now observe the micrograph of deLavaud Pipe. Note the smallness of the graphite masses and the fine even texture of the metal. This density and the uniformity of grain structure give deLavaud pipe a tensile strength of more than 30,000 lbs. per sq. inch.

Indeed, exhaustive laboratory and factory tests have proved that deLavaud Cast Iron Pipe is 25% stronger than pipe cast by any other method.

deLAVAUD CAST IRON PIPE

centrifugally cast by

United States Cast Iron Pipe and Foundry Company

General Offices:

Burlington, New Jersey

SALES OFFICES

Philadelphia
Chicago
Birmingham
Buffalo
Cleveland
New York
San Francisco
Los Angeles
Pittsburgh
Dallas
Kansas City
Seattle
Minneapolis

Corrosion of Iron and Steel Water Pipes

Information on this subject is desired by the Committee recently appointed by the Association "to Collect and Correlate Information Concerning the Corrosion of Iron and Steel Pipes and Standpipes." Members are urged to send data relating to the characteristics of the metal, the soil, the water and the protective coatings and to the history and condition of such supply mains (not service pipes) to the undersigned for the use of the Committee.

CALEB MILLS SAVILLE, *Chairman.*
1026 Main Street, Hartford, Conn.

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON

WATER & GAS PIPES

FLANGE PIPE

Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

WOOLWORTH BUILDING **233 BROADWAY**

NEW YORK CITY

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments

use

LEAD-LINED IRON and TIN-LINED PIPES

for their service connections

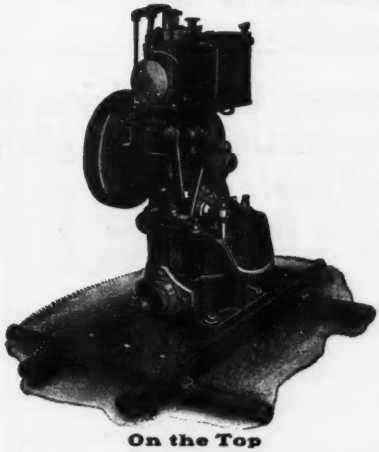
MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield ═══ Mass.

Edson Manufacturing Corp.

375 BROADWAY, BOSTON, MASS.



On the Top

NO. 1 AIR-COOLED GASOLINE ENGINE
Can be attached to any Diaphragm Pump

This Engine is built for Diaphragm Pumps by the makers and inventors of the Pump.

Fifty years' experience is behind it — reliable as the original pump you have known for years.

Now in use by many of the Water Departments.

Mounted on Skid or 4-Wheel Hand Truck, also either Battery or Magneto Ignition.

Warren Foundry and Pipe Co.

(Formerly Warren Foundry and Machine Co.)

SALES OFFICES

11 BROADWAY, NEW YORK

201 DEVONSHIRE ST., BOSTON, MASS.

Telephone, Fort Hill 5951

CAST IRON PIPE

Bell and Spigot Flanged Pipe

Special Castings

Flexible Joint Pipe Cylinders

Water Gas Sewers Culverts

Works, Phillipsburg, N. J.

LARGE STOCK ENABLES US TO MAKE QUICK SHIPMENTS

TRADE **"LEADITE"** MARK

Registered U. S. Pat. Office

Only 51 days between the decision to build an emergency water works plant - - *and the finished job!*

- - the speed with which Leadite jointing can be accomplished contributed to this remarkable feat.

THE line illustrated here is 26,000 ft. of 12″ pipe with LEADITE joints.

Owing to the emergency which arose in the city for which the installation was made no trenching could be attempted.

The line lies throughout its entire length on the surface of the ground without any bracing except at the bends.

After completion the line was tested to 260 lbs. pump pressure.

It is now under constant pump working pressure of 230 lbs. For over 30 years now, LEADITE has demonstrated by test and experience that it is absolutely permanent and secure.

Leadite is self-caulking and is so simple to use that the method of using it can be taught to even the most inexperienced help in a very short time.

Added to its speed and ease of use — Leadite saves at least 75% on account of saving in material and labor.

Part of the 26,000 ft. installation, crossing an open field. Chas. E. Waddell & Co., Engineers.

Specify and use LEADITE —it saves at least 75%

Be sure it is LEADITE and accept no imitations : :

The pioneer self-caulking material for c. i. pipe. Tested and used for over 30 years.

THE LEADITE COMPANY Land Title Bldg. PHILADELPHIA, PA.

NO CAULKING

Chadwick-Boston Lead Co.

800 Albany St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

PIG LEAD

Joints that are Stress and Vibration Proof

Unusual situations often met in laying bell and spigot pipe — lines over bridges or railroad crossings — lines to be lowered to grade — are successfully met when the joints are made with Hydro-Tite.

Easy to Prepare

The 8-in. line pictured above is slung across a pond with cables — a span of more than fifty feet.

Every test shows that Hydro-Tite joints will remain perfectly tight when subjected to severe vibration or deflection. If you have never used Hydro-Tite let us tell you more about it. Requires no caulking — 19 years of proven dependability — a real 75% saving and an ever-increasing list of satisfied users.

Easy to Pour

Write for literature and further information.

HYDRAULIC DEVELOPMENT CO.

50 Church St., New York, N. Y.

BOSTON OFFICE & WORKS
296 Boylston St.

CHICAGO OFFICE
7 So. Dearborn St.

HYDRO-TITE

REG. U. S. PAT. OFF.

The Modern Joint Material

"The Goods That Please"

Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

Let us send at our risk, on 30 days' trial, a

Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

Established 1869

New!
SERVICE BOXES
With *Stay-on* Covers
Just what you have been waiting for... Interchangeable with "Buffalo" boxes....
Ask for Monitor Service Box catalog.

THE CAST IRON PIPE THAT MAKES ITS OWN JOINTS

East Jaffrey, N. H.

Here's dependable water supply for you!

Dependable because it's 100% cast iron. No hot lead, no cold lead, no lead substitutes, no pouring, no calking. Nothing to work loose, nothing to deteriorate in these flexible, dependable joints—machined iron-to-iron *joints as tight as the wall of the pipe itself.*

Wrenches the only tools. Address nearest office.

UNIVERSAL CAST IRON PIPE
No hell holes to dig. No joints to calk.
THE CENTRAL FOUNDRY COMPANY
Subsidiary of The Universal Pipe and Radiator Company
Graybar Building, 420 Lexington Avenue
Chicago Birmingham New York Dallas San Francisco

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Altitude Valves

We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves":
1st —Automatically, by water.
2nd—By Electricity, if desired.
3rd—By Hand

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. No valves or fixtures inside or outside.

Sizes to 24 in.

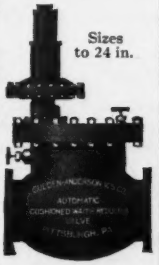
Remember!

"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

"Made with stop starter attachment for centrifugal pumps"

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required — No attention necessary.
5. Positively no hammering or sticking.



Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle — Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.

Angle or Globe

Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Double Cushioned Check Valve

Sizes to 24 in. Angle or Globe

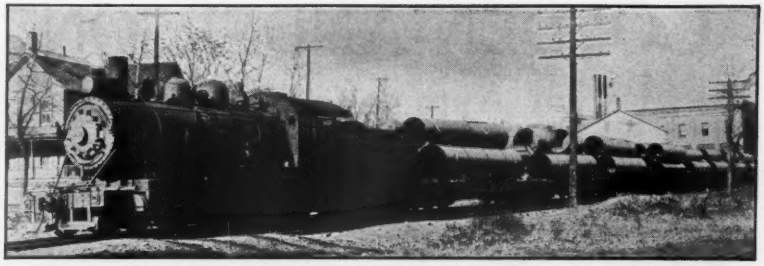
Automatically prevents reverse flow of pressure.

Perfectly cushioned to prevent shock or hammer.

Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping.

Arranged so that quick or slow operating may be obtained.

Golden-Anderson Valve Specialty Co., 1325 Fulton Bldg., Pittsburgh, Pa.



By the trainload! Biggs Pipe goes out to cover large and small installations everywhere.

Put BIGGS in your pipe program

— because Biggs Steel Pipe, both riveted and welded, has earned your confidence!

Biggs Water Pipe Line Service is complete from steel fabrication in a modern plant operating exclusively on heavy steel plate work, to assembly on the job, under Biggs' supervision.

Here are some typical Biggs' installations: —

BOSTON, MASS. (Metropolitan District Commission)
(13,300 ft. 54″ riveted pipe — Chestnut Hill project)
(7,380 ft. 60″ riveted pipe — Brookline project)

NEW YORK CITY (Board of Water Supply)
(15,250 ft. 72″ riveted pipe)

NEW YORK CITY (Dept. of Water Supply, Gas and Electricity)
(7,900 ft. 30″ Electric welded pipe)
(3,010 ft. 36″ Electric welded pipe)

FLINT, MICH. (Pressure Sewage Line)
(16,250 ft. 50″ riveted pipe)

Biggs' experience in the fabrication of riveted and welded steel pipe, plus modern plant equipment and specially organized construction forces, is the engineer's assurance of a satisfactory installation.

THE BIGGS BOILER WORKS COMPANY
Akron, Ohio
Eastern Sales Office: 300 Madison Ave., New York City

BIGGS Steel Pipe ***Riveted and Welded***

The Biggs Boiler Works Co. Akron Ohio

Will it deliver a full supply of Clear Rust-Free Water?

THAT is one of the most important questions you will have to ask yourself in ordering service pipe.

Satisfactory service and economy depend upon the ability of the pipe to withstand soil corrosion on the outside and internal corrosion from the flow of water on the inside.

You can get such service from Rust-Proof Copper or its alloys—the materials that will always deliver a full supply of pure, clear water, free from rust contamination. Rust-Proof Copper is easy to install.

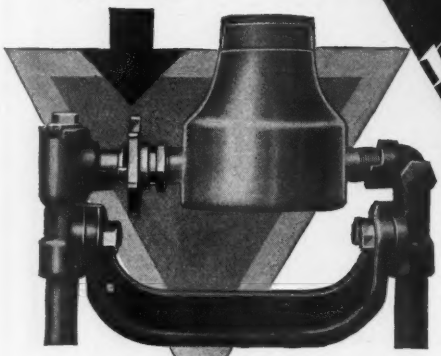
Before you order service pipe read this brochure. It will be ready for distribution February 15th. Write for your free copy.

COPPER & BRASS
RESEARCH ASSOCIATION
25 Broadway, New York

Midwestern Office	*Canadian Office*	*Pacific Coast Office*
Landreth Building	67 Yonge Street	Architects Building
St. Louis, Mo.	Toronto, Ont.	Los Angeles, Cal.

COPPER, BRASS, BRONZE—*The World's Most Useful Metals*

THE FORD EXPANSION CONNECTION

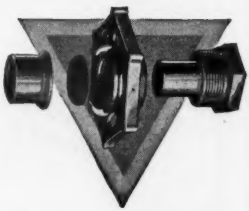


Save time and money!

...with the FORD EXPANSION CONNECTION

THE Ford Expansion Connection furnished with the Ford Yoke is *unique, outstanding!* There is nothing else like it in principle or convenience...*internal expansion outward* against fixed ports and gaskets. It makes possible the removal or placing of a meter without the use of a wrench.

Just a few turns of the large *handwheel* makes or unmakes a water tight joint. All moving parts are of bronze and are removed with the meter which prevents bridging through to steal water. Tens of thousands of Ford Yokes in use for many years prove their dependability.



Connection is screwed on meter spud with a wrench. The meter with Connection attached is dropped in the saddles of the yoke where rubber gaskets are held in recessed ports. Turning the handwheel expands the connection, making a perfect compression joint.

Send for Bulletin

WATER METER SETTINGS & TESTING EQUIPMENT

THE FORD METER BOX CO.

WABASH, INDIANA

LaMotte

SLUDGE TESTING SET

THIS improved apparatus for determining the pH of sewage sludges is the result of recent research which shows that sewage sludges can be diluted to a considerable degree without changing their pH values. It eliminates the necessity for filtering or centrifuging, while difficulties due to turbidity or color are overcome by the use of a special comparator and color standards. Accurate results are obtained with rapidity and the set is compactly arranged so that it may be conveniently carried.

Price, complete with instructions $30.00
f.o.b. Baltimore.

LaMotte B. O. D. Set

Based on the Sierp method and gives consistent results in determining the biochemical oxygen demand of sewage and industrial wastes.

Price, complete with instructions $7.50
f.o.b. Baltimore.

LaMotte Chemical Products Company

428 Light Street . . . . Baltimore, Md., U. S. A.

CLASSIFIED DIRECTORY OF ADVERTISEMENTS.

PAGE

AIR COMPRESSORS.
Hayes Pump and Machinery Co. . . . xix
Murray Iron Works Co. . . . xx
Worthington Pump & Machinery Corp. . . . viii

ALUM.
Merrimac Chemical Co. . . . xxiv

BOILER SETTINGS.
Boston Pipe & Fittings Co. . . . xxvii
Starkweather & Broadhurst . . . xviii

BOILERS, STEAM.
Massur, F. A., & Co. . . . xvii
Murray Iron Works Co. . . . xx
Starkweather & Broadhurst . . . xviii

BRASS GOODS.
(See also Pipe, Brass.)
Boston Pipe & Fittings Co. . . . xxvii
Caldwell, George A., Co. . . . xxxiv
Cement Lined Pipe Co. . . . xxvii
Copper & Brass Research Association . . . xlvi
Hays Mfg. Co. . . . xli
Mueller Co. . . . xvi
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii
The A. P. Smith Mfg. Co. . . . xxiv
Union Water Meter Co. . . . xi
Ware Coupling & Nipple Co. . . . xxv

CALKING MACHINERY AND TOOLS.
Mueller Co. . . . xvi
The A. P. Smith Mfg. Co. . . . xxiv

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Wallace and Tiernan Co., Inc. . . . xxiii

CHEMICALS FOR WATER PURIFICATION.
Merrimac Chemical Co. . . . xxiv

CHLORINATORS.
Paradon Mfg. Co. . . . liii
Wallace & Tiernan Co., Inc. . . . xxiii

CHLORINE COMPARATORS.
LaMotte Chemical Products Co. . . . xlvii

CLEANING WATER MAINS.
General Pipe Cleaning Co. . . . iii
National Water Main Cleaning Co. . . . xxx

COCKS, CURB AND CORPORATION.
Boston Pipe & Fittings Co. . . . xxvii
Caldwell, George A., Co. . . . xxxiv
Hays Mfg. Co. . . . xli
Mueller Co. . . . xvi
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii
The A. P. Smith Mfg. Co. . . . xxiv
Union Water Meter Co. . . . xi

CONCRETE PIPE.
(See Pipe, Concrete.)

CONDENSERS.
Hayes Pump and Machinery Co. . . . xix
Massur, F. A., & Co. . . . xvii
Starkweather & Broadhurst . . . xviii
Worthington Pump & Machinery Corp. . . . viii

CONSTRUCTION EQUIPMENT.
Edson Mfg. Corp. . . . xxxvii

CONTRACTORS.
Ferullo, G., Co. . . . iii
National Water Main Cleaning Co. . . . xxx

CURB BOXES.
Bingham and Taylor . . . v
Caldwell, George A., & Co. . . . xxxiv
Clark, H. W., Co. . . . xxiv
Hays Mfg. Co. . . . xli
Mueller Co. . . . xvi
Sumner & Dunbar . . . xxvii

CURB AND VALVE BOX FINDERS.
Caldwell, George A., Co. . . . xxxiv

DIAPHRAGMS, PUMP.
Edson Mfg. Corp. . . . xxxvii

ENGINEERS.
Ambursen Construction Co. . . . ii
Barbour, Frank A. . . . ii
Barrows, H. K. . . . ii
Conard & Busby . . . ii
Fay, Spofford & Thorndike . . . ii
Fuller & McClintock . . . ii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*.

ENGINEERS — *Continued* — Page

Hazen, Everett & Pirnie . . . ii
Main, Charles T. . . . ii
Metcalf & Eddy . . . ii
Symonds, Henry A. . . . iii
Thorpe, Lewis D. . . . iii
Weston & Sampson . . . ii

ENGINES.
(See Pumps and Pumping Engines.)

ERECTORS, WATER WORKS AND POWER MACHINERY.
Hayes Pump and Machinery Co. . . . xix
Massur, F. A., Co. . . . xvii
Power Equipment Co. . . . xix
Starkweather & Broadhurst . . . xviii
Turbine Equipment Co. . . . xxii

FEED WATER HEATERS.
Hayes Pump and Machinery Co. . . . xix
Massur, F. A., & Co. . . . xvii
Ross Valve Mfg. Co. . . . xxx
Starkweather & Broadhurst . . . xviii
Worthington Pump & Machinery Corp. . . . viii

FILTER RATE CONTROLLERS AND GAGES.
(See Rate Controllers.)

FILTERS AND WATER SOFTENING PLANTS.
Ross Valve Mfg. Co. . . . xxx

FILTRATION PLANT EQUIPMENT.
Builders Iron Foundry . . . ix
Ross Valve Mfg. Co. . . . xxx
Wallace & Tiernan Co., Inc. . . . xxiii

FLEXIBLE JOINTS.
U. S. Cast Iron Pipe and Foundry Co. . . . xxxv

FURNACES, ETC.
Mueller Co. . . . xvi
The A. P. Smith Mfg. Co. . . . xxiv
The Leadite Co. . . . xxxviii

GAGES, SURFACE, RESERVOIR AND SPECIAL WATER WORKS.
Builders Iron Foundry . . . ix
Clark, H. W., Co. . . . xxiv

GAS ENGINES.
Worthington Pump & Machinery Corp. . . . viii

GATE VALVES. (See Valves.)

GRIP PIPE FITTINGS.
Ware Coupling & Nipple Co. . . . xxvii

HOSE, SUCTION AND CONDUCTION.
Edson Mfg. Corp. . . . xxxvii

HYDRANTS, FIRE.
Chapman Valve Mfg. Co. . . . xxxii
Eddy Valve Co. . . . xxxiii
Fox, John, & Co. . . . xxxvi
Kennedy Valve Mfg. Co. "Newtype" . . . xxix
Ludlow Valve Mfg. Co. . . . xxxi
Rensselaer Valve Co. "Corey" . . . xxxi
Ross Valve Mfg. Co. . . . xxx
The A. P. Smith Mfg. Co. . . . xxiv
Wood, R. D., & Co. . . . xxviii

HYDRANTS, SPRINKLING AND FLUSHING.
Mueller Co. . . . xvi

HYDROGEN ION EQUIPMENT
LaMotte Chemical Products Co. . . . xlvii

INSPECTION OF MATERIALS.
Conard & Buzby . . . ii

LEAD.
Chadwick-Boston Lead Co. . . . xxxix

LEAD PIPE.
(See Pipe, Lead.)

LEAD WOOL.
Chadwick-Boston Lead Co. . . . xxxix

LEAK FINDERS.
Clark, H. W., Co. . . . xxiv
Pitometer Co. . . . iii

LIME.
Merrimac Chemical Co. . . . xxiv

LIQUID CHLORINE.
(See Chlorine, Liquid.)

METERS, WATER AND OIL.
Badger Meter Mfg. Co. . . . xv
Buffalo Meter Co. . . . x
Builders Iron Foundry . . . ix
Gamon Meter Co. . . . xiii
Hersey Mfg. Co. . . . iv
National Meter Co. . . . xiv
Neptune Meter Co. . . . vi
Pitometer Co. . . . iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*.

PAGE

METERS — *Continued*
Pittsburgh Equitable Meter Co. . . . vii
Simplex Valve & Meter Co. . . . vii
Union Water Meter Co. . . . xi
Worthington Pump and Machinery Corp. . . . viii

METER COUPLINGS.
Clark, H. W., Co. . . . xxiv
Ford Meter Box Co. . . . xlvi
Mueller Co. . . . xvi

METERS, (VENTURI TYPE).
Builders Iron Foundry . . . ix
National Meter Co. . . . xiv
Simplex Valve & Meter Co. . . . xii

METER BOXES.
Bingham and Taylor . . . v
Clark, H. W., Co. . . . xxiv
Ford Meter Box Co. . . . xlvi

METER TESTERS.
Clark, H. W., Co. . . . xxiv
Ford Meter Box Co. . . . xlvi
Mueller Co. . . . xvi

OIL ENGINES, DIESEL.
Fairbanks-Morse & Co. . . . xxi
Hayes Pump and Machinery Co. . . . xix
Worthington Pump and Machinery Corp. . . . viii

OIL, GREASE, ETC.
Dixon, Jos., Crucible Co. . . . xix

PAINT.
Dixon, Jos., Crucible Co. . . . xix

PIPE, BRASS.
Boston Pipe & Fittings Co. . . . xxvii
Copper & Brass Research Association . . . xlv
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii

PIPE, CAST IRON (AND FITTINGS).
Builders Iron Foundry . . . ix
Central Foundry Co. . . . xliii
Donaldson Iron Co. . . . xxxiv
Fox, John, & Co. . . . xxxvi
Houdlette, Fred A., & Son . . . xxvii
McWane Cast Iron Pipe Company . . . xxv
U. S. Cast Iron Pipe and Foundry Co. . . . xxxv
Warren Foundry and Pipe Co. . . . xxxvii
Wood, R. D., & Co. . . . xxviii

PIPE, CEMENT LINED.
Cement Lined Pipe Co. . . . xxvii
Union Water Meter Co. . . . xi

PIPE, CONCRETE.
Lock Joint Pipe Co. . . . Facing front cover

PIPE COVERING — WOODEN FOR STEAM PIPING.
Michigan Pipe Co. . . . Back Cover

PIPE CUTTING MACHINES.
The A. P. Smith Mfg. Co. . . . xxiv

PIPE JOINTING MATERIAL.
Dixon, Jos., Crucible Co. . . . xix
Hydro-Tite . . . xl
The Leadite Co. . . . xxxviii

PIPE, LEAD.
Chadwick-Boston Lead Co. . . . xxxix

PIPE, LEAD LINED.
Lead Lined Iron Pipe Co. . . . xxxvi

PIPE LOCATORS.
Clark, H. W., Co. . . . xxiv

PIPE PUSHERS.
Clark, H. W., Co. . . . xxiv

PIPE, TIN LINED.
Lead Lined Iron Pipe Co. . . . xxxvi

PIPE, UNIVERSAL.
Central Foundry Co. . . . xliii

PIPE, WOOD.
Michigan Pipe Co. . . . Back Cover

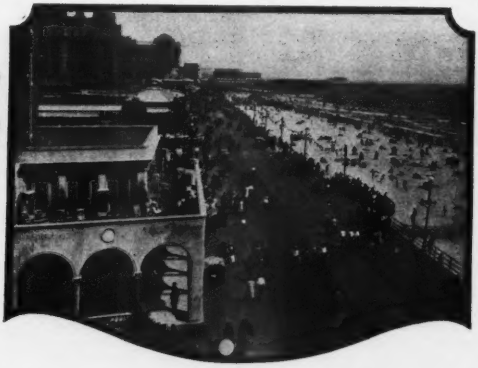
PIPE, WROUGHT IRON AND STEEL.
Biggs Boiler Works Co. . . . xliv
Boston Pipe & Fittings Co. . . . xxvii
Byers, A. M., Co. . . . xxvi
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii

PITOMETERS.
Pitometer Co. . . . iii

PRESSURE REGULATORS.
Caldwell, George A., Co. . . . xxxiv
Golden-Anderson Valve Specialty Co. . . . xliii
Mueller Co. . . . xvi
Ross Valve Mfg. Co. . . . xxx
Union Water Meter Co. . . . xi

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).

	Page
PROVERS, WATER.	
Pittsburgh Equitable Meter Co.	vii
PUMPS AND PUMPING ENGINES.	
Edson Manufacturing Corp.	xxxvii
Fairbanks-Morse & Co.	xxi
Hayes Pump and Machinery Co.	xix
Massur, F. A., Co.	xvii
Murray Iron Works Co.	xx
Power Equipment Co.	xix
Ross Valve Mfg. Co.	xxx
Starkweather & Broadhurst	xviii
Turbine Equipment Co.	xxii
Wood, R. D., & Co.	xxviii
Worthington Pump and Machinery Corp.	viii
RATE CONTROLLERS.	
Builders Iron Foundry	ix
Simplex Valve & Meter Co.	xii
SERVICE CLAMPS, GALVANIZED.	
Mueller Co.	xvi
SLEEVES AND VALVES, TAPPING.	
Ludlow Valve Mfg. Co.	xxxi
Mueller Co.	xvi
Rensselaer Valve Co.	xxxi
The A. P. Smith Mfg. Co.	xxiv
SODA ASH.	
Merrimac Chemical Co.	xxiv
STACKS.	
Starkweather & Broadhurst	xviii
SULPHATE OF ALUMINA. (See Alum.)	
SUPPLIES AND TOOLS.	
Boston Pipe & Fittings Co.	xxvii
Caldwell, George A., Co.	xxxiv
Hays Mfg. Co.	xli
Leadite Co.	xxxviii
Mueller Co.	xvi
Pierce-Perry Co.	xxvii
Sumner & Dunbar	xxvii
The A. P. Smith Mfg. Co.	xxiv
TANK PAINT.	
M. B. Main	xxv
TANKS, STEEL.	
Murray Iron Works Co.	xx
TAPPING MACHINES.	
Hays Mfg. Co.	xli
Mueller Co.	xvi
The A. P. Smith Mfg. Co.	xxiv
TAPPING SLEEVES. (See Sleeves and Valves, Tapping.)	
UNIVERSAL PIPE. (See Pipe, Universal.)	
VALVE BOXES.	
Bingham and Taylor	v
Clark, H. W., Co.	xxiv
Ford Meter Box Co.	xlvi
Rensselaer Valve Co.	xxxi
Wood, R. D., & Co.	xxviii
VALVE INSERTING MACHINES.	
The A. P. Smith Mfg. Co.	xxiv
VALVE SPECIALTIES.	
Golden-Anderson Valve Specialty Co.	xliii
VALVES, GATE.	
Boston Pipe & Fittings Co.	xxvii
Chapman Valve Mfg. Co.	xxxii
Eddy Valve Co.	xxxiii
Fox, John, & Co.	xxxvi
Kennedy Valve Mfg. Co.	xxix
Ludlow Valve Mfg. Co.	xxxi
Rensselaer Valve Co.	xxxi
Ross Valve Mfg. Co.	xxx
Simplex Valve & Meter Co.	xii
The A. P. Smith Mfg. Co.	xxiv
Wood, R. D., & Co.	xxviii
VALVES, REGULATING.	
Golden-Anderson Valve Specialty Co.	xliii
Mueller Co.	xvi
Ross Valve Mfg. Co.	xxx
Union Water Meter Co.	xi
WATER WASTE DETECTION.	
Pitometer Co.	iii
Simplex Valve & Meter Co.	xii
WOOD PIPE. (See Pipe, Wood.)	
WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)	



And now another
PARADON
for Atlantic City!

In 1925 the Water Department of Atlantic City installed their first Paradon Chlorinator.

In 1928 increased capacity made a second chlorinator necessary — and of course it was a PARADON — and Atlantic City is but one of a long list of Paradon repeat orders. The cardinal feature of all Paradon Chlorinators is Simplicity. Also, the Paradon has fewest parts and sturdiest construction. All threads and fittings are standard; and every Paradon is mounted on a handsome white vitrified enamelled pedestal. It is a handsome apparatus and, what's more, it looks as good five years after as it did on the day it was installed.

Send for Bulletin N-4

PARADON MFG. CO.
Arlington, N. J.

Paradon
CHLORINATORS
for -
City and Private Water and Sewage Systems,
Industrial Plants and Swimming Pools.

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness. ALL MEMBERS OF THE ASSOCIATION RECEIVE THE JOURNAL IN PART RETURN FOR THEIR ANNUAL DUES; to all others the subscription is four dollars per annum.

TO ADVERTISERS

THE attention of parties dealing in goods used by Water Departments is called to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS and CONTRACTORS in the United States. The paid circulation is **900** COPIES.

Being filled with original matter of the greatest interest to Water Works officials, it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertisements being inserted solely to help meet the large expense of publication.

ADVERTISING RATES.

One page, one year, four insertions	Eighty Dollars.
One-half page, one year, four insertions	Fifty-six Dollars.
One-fourth page, one year, four insertions	Thirty-six Dollars.
One-twelfth page (card), one year, four insertions	Twelve Dollars.
One page, single insertion	Forty Dollars.
One-half page, single insertion	Thirty Dollars.
One-fourth page, single insertion	Twenty Dollars.

Size of page, 4½ x 7½ net.

A sample copy will be sent on application.

For further information, address,

GORDON M. FAIR, Editor,
112 PIERCE HALL,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

The Post Hill Press
SAMUEL USHER
BOSTON, MASSACHUSETTS

MICHIGAN
COMBINATION STEEL AND WOOD
WATER PIPE

12 000 feet — 18-inch Wood at Athol, Mass.

Michigan Pipe Company, BAY CITY MICHIGAN

Chicago, Ill., 624 So. Michigan Ave.: F. C. JUSTICE
New York City, 522 Fifth Ave.: WYCKOFF PIPE & CREO. CO.
Chattanooga, Tenn., 703 James Bldg.: NIXON-HASSELLE CO.
Philadelphia, Pa., 1228 Spruce Street: C. E. BROWN
Cleveland, Ohio, 919 Ulmer Bldg.: MORRISON EQUIPMENT CO.
Oklahoma City, Okla., 320 W. 26th Street: F. X. LOEFFLER

MINOT S. KAHURL
Eastern Sales Manager
ROOM 1121, OLIVER BUILDING
141 MILK STREET - BOSTON, MASS.
Telephone: Congress 2481